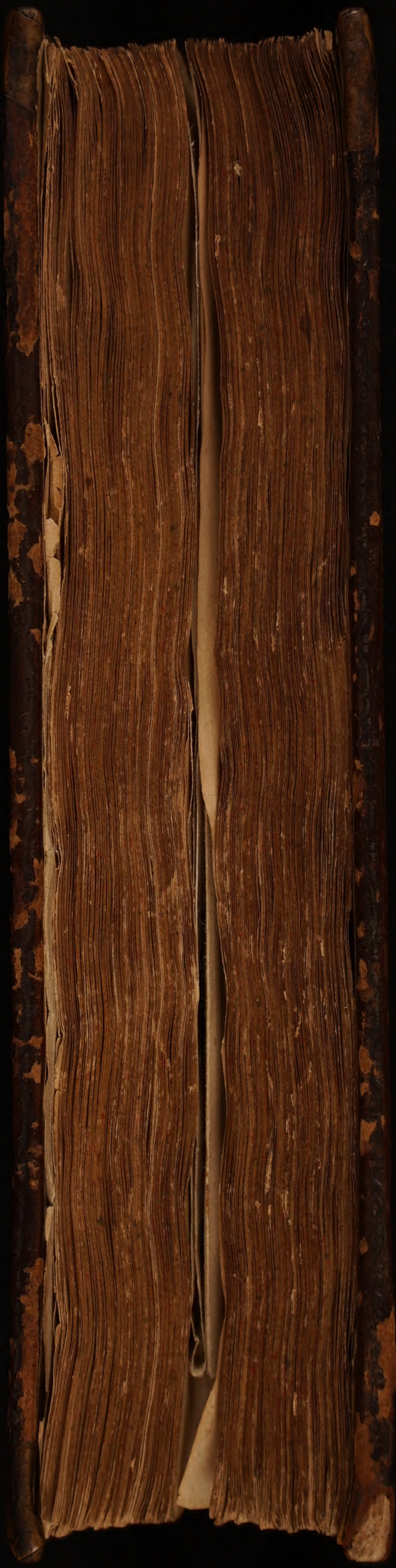


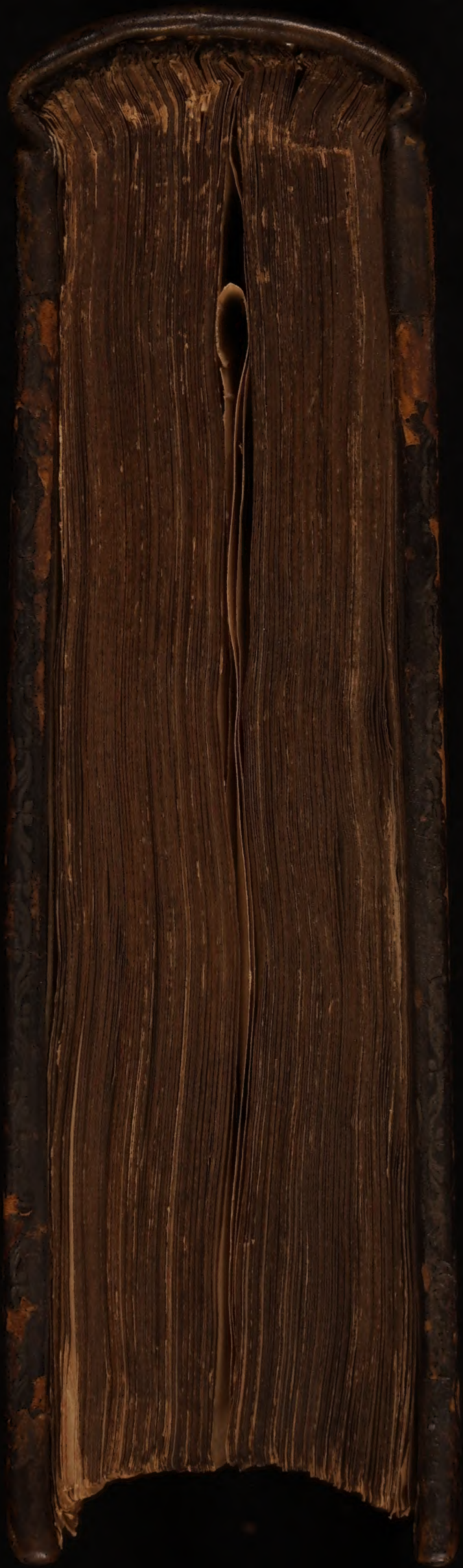
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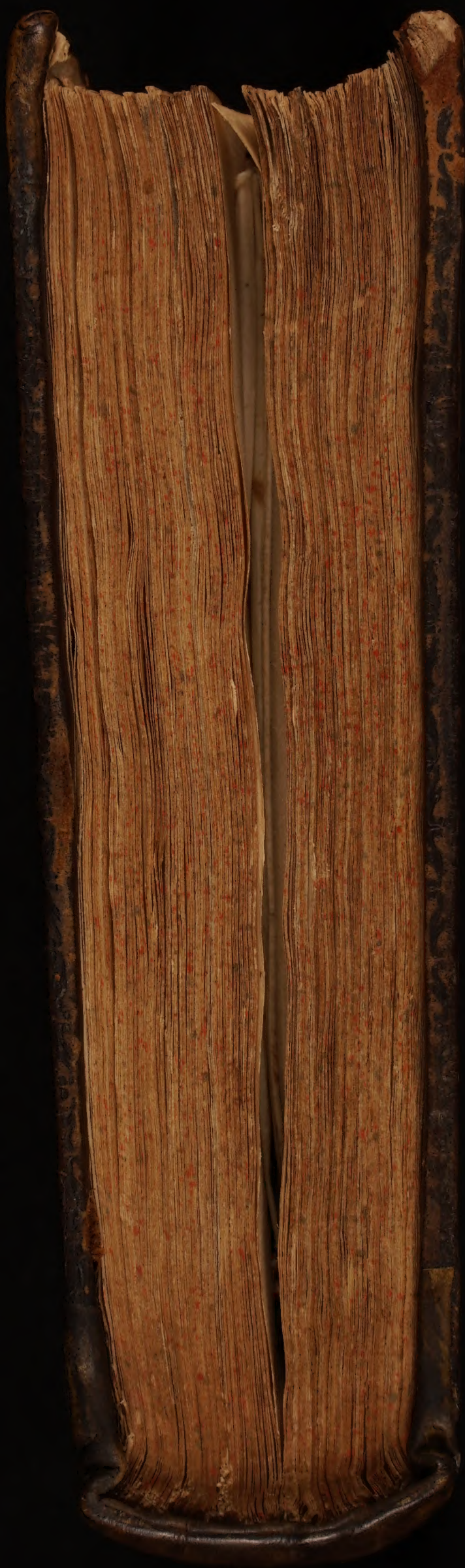
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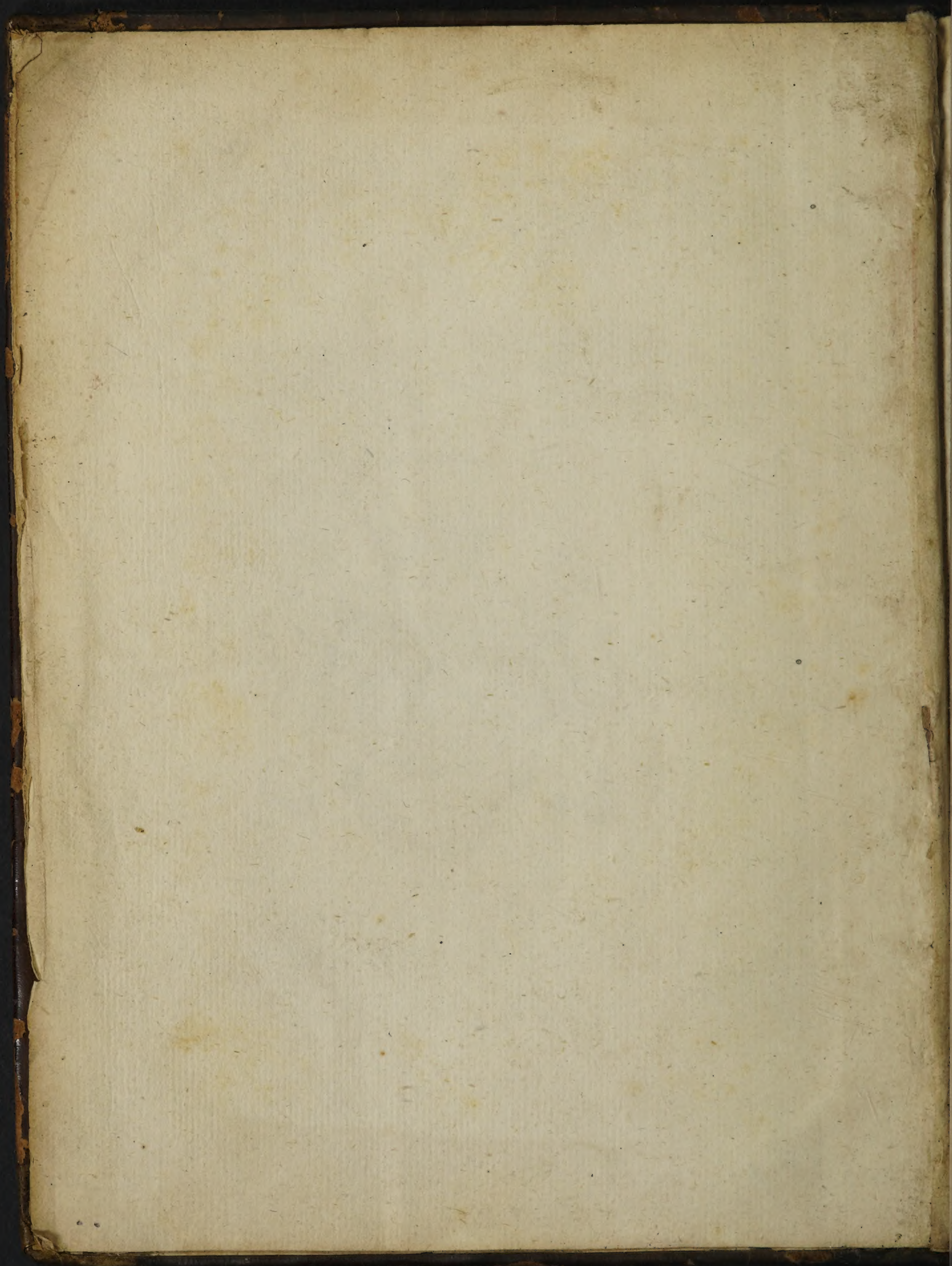


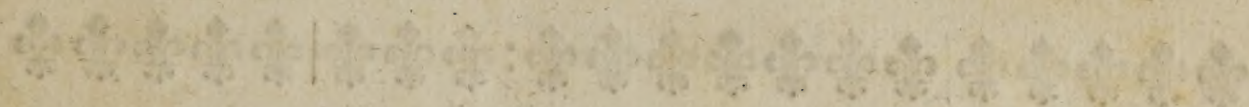
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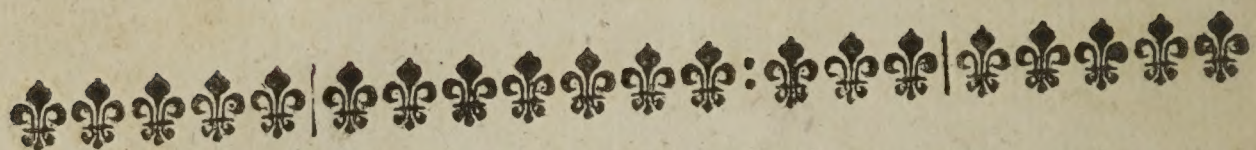


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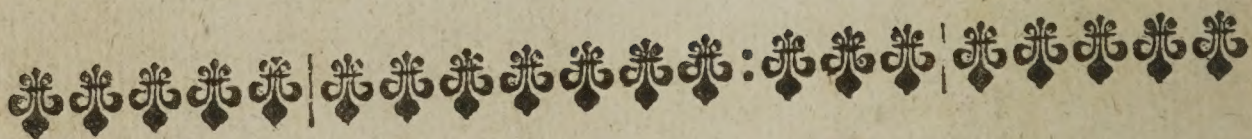




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Aug. 5. 1663.*

*Geo. Stradling, S. T. P. Rev. in
Christo Patr. D. Gilb. Episc. Lond.
à Sac. Domestic.*



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EXPERIMENTAL
PHILOSOPHY,
In Three Books :

Containing

New Experiments } Microscopical,
 } Mercurial,
 } Magnetical.

With some *Deductions*, and Probable *Hypotheses*, raised from
them, in Avouchment and Illustration of the now famous
Atomical Hypothesis.

By HENRY POWER, Dr. of Physick.

Perspicillum (Microscopicum scilicet) si vidisset Democritus, exilisset fortè; &
modum videndi Atomum (quam ille invisibilem omnino affirmavit) inventum fuisse pu-
tasset. Fr. Verulam. lib. 2. Novi Organi, sect. 39.

Hinc igitur facillimè intelligere possumus, quam stultiè, quam inaniter sese venditat hu-
mana sapientia, quòve ferantur nostra Ingenia, nisi recta ratione, experiètiâque (scientia-
rum omnium magistra) nitantur. & opinionis salebras accuratè vitent. Muffet. De Insect.
cap. 15. pag. 115.

L O N D O N,

Printed by T. Roycroft, for John Martin, and James Allestry,
at the Bell in S. Pauls Church-yard. 1664.



*S^r John Leveson Gower of Trentham
in Stafford Shire Baronet.*





The Preface to the Ingenious R E A D E R.

DIoptrical Glasses (which are now wrought up to that height and curiosity we see) are but a Modern Invention : Antiquity gives us not the least hint thereof, neither do their Records furnish us with any thing that does Antedate our late discoveries of the Telescope, or Microscope. The want of which

The Preface.

*incomparable Artifice made them not
onely erre in their fond Cælestial Hy-
pothesis, and Crystalline wheel-work
of the Heavens above us, but also in
their nearer Observations of the mi-
nute Bodies and smallest sort of Crea-
tures about us, which have been by
them but sleightly and perfunctori-
ly described, as being the disregard-
ed pieces and huslement of the Cre-
ation; when (alas!) those sons of
Sense were not able to see how cu-
riously the minutest things of the
world are wrought, and with what
eminent signatures of Divine Provi-
dence they were enrich'd and embel-
lish'd,*

The Preface.

lish'd, without our Dioptrical assistance. Neither do I think that the Aged world stands now in need of Spectacles, more than it did in its primitive Strength and Lustre: for howsoever though the faculties of the soul of our Primitive father Adam might be more quick & perspicacious in Apprehension, than those of our lapsed selves; yet certainly the Constitution of Adam's Organs was not divers from ours, nor different from those of his Fallen Self, so that he could never discern those distant, or minute objects by Natural Vision, as we do by the Artificial advantages of the

The Preface.

the Telescope and Microscope. So that certainly the secondary Planets of Saturn and Jupiter and his Annular appearances, the Maculæ Solis, and Lunations of the inferiour Planets, were as obscure to him as unknown to his Posterity; onely what he might ingeniously guess at by the Analogie of things in Nature, and some other advantageous Circumstances.

And as those remote objects were beyond the reach of his natural Opticks, so doubtless the Minute Atoms and Particles of matter, were as unknown to him, as they are yet unseen by us: for

cer-

The Preface.

certainly both his and our Eyes were framed by providence in Analogie to the rest of our senses, and as might best manage this particular Engine we call the Body, and best agree with the place of our habitation (the earth and elements we were to converse with) and not to be critical spectators, surveyors, and adequate judges of the immense Universe: and therefore it hath often seem'd to me beyond an ordinary probability, and something more than fancy (how paradoxical soever the conjecture may seem) to think, that the least Bodies we are able to see with our naked eyes, are

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but

The Preface.

but middle proportionals (as it were) 'twixt the greatest and smallest Bodies in nature, which two Extremes lye equally beyond the reach of humane sensation: For as on the one side they are but narrow souls, and not worthy the name of Philosophers, that think any Body can be too great or too too vast in its dimensions; so likewise, are they as inapprehensive, and of the same litter with the former, that on the other side think the particles of Matter may be too little, and that nature is stinted at an Atom, and must have a non ultra of her subdivisions.

Such

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Such, I am sure, our Modern Engine (the Microscope) wil ocularly evince and unlearn them their opinions again : for herein you may see what a subtil divider of matter Nature is ; herein we can see what the illustrious wits of the Atomical and Corpuscularian Philosophers durst but imagine, even the very Atoms and their reputed Indivisibles and least realities of Matter, nay the curious Mechanism and organical Contrivance of those Minute Animals, with their distinct parts, colour, figure and motion, whose whole bulk were to them almost invisible : so that

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were Aristotle now alive, he might write a new *History of Animals*; for the first Tome of *Zoography* is still wanting, the Naturalists hitherto having onely described unto us the larger and more voluminous sort of *Animals*, as *Bulls*, *Bears*, *Tygers*, &c. whilst they have regardlessly pass'd by the *Insectile Automata*, (those *Living-exiguities*) with only a bare mention of their names, whereas in these pretty *Engines* (by an *Incomparable Stenography* of *Providence*) are lodged all the perfecti-
ons of the largest *Animals*; they have the same organs of body, multiplicity
of

The Preface.

of parts, variety of motions, diversity of figures, severality of functions with those of the largest size: and that which augments the miracle, is, that all these in so narrow a room neither interfere nor impede one another in their operations. Who therefore with the Learned * Doctor, admires not * Dr. Brown, Regiomontanus his Fly beyond Relig. Med. his Eagle, and wonders not more at the operation of two souls in those minute bodies, than but one in the trunk of a Cedar? Ruder heads stand amazed at those prodigious and Colossean pieces of Nature, as Whales, Elephants, and Dromedaries; but in these nar-

The Preface.

narrow Engines there is more curious Mathematicks, and the Architecture of these little Fabricks more neatly set forth the wisdom of their Maker.

Now as Matter may be great or little, yet never shrink by subdivision into nothing; so, is it not probable, that Motion also may be indefinitely swift or slow, and yet never come to a quiescency? and so consequently there can be no rest in Nature, more than a Vacuity in Matter. The following Observations seem to make out, that the Minute particles of most (if not all) Bodies are constantly in some kind of

of

The Preface.

of motion, and that motion may be both invisibly and unintelligibly slow, as well as swift, and probably is as unseparable an attribute to Bodies, as well as Extension is.

And indeed, if the very nature of fluidity consist in the Intestine motion of the parts of that Body call'd fluid, as Des-Cartes happily supposed, and M^r. Boyle has more happily demonstrated, Why may we not be bold both to think and say, that there is no such thing in the World as an absolute quiescence? for I. the greatest part of the World (viz. the ætherial Medium (wherein all the Stars
and

The Preface.

and Planets do swim) is now confess'd
by all to be fluid, and so, consequently,
in a Perpetual Motion. 2. All the
fixed lights of Heaven are generally
concluded to be pure Fire, and so con-
sequently fluid also, and then subcon-
sequentially in motion also; not to
mention the diurnal Rotations of
their whole Bodies, which every one
is supposed to have, as well as our Sun:
and as for the Opake and Planetary
Bodies of the Universe, they are all
porous, and the ætherial Matter is
continually streaming through them,
their internal fire and heat constantly
subliming Atoms out of them, the
Magne-

The Preface.

Magnetical Atoms continually playing about them : Not to mention also their dietical Motions about their own Axes, and circumrevolutions about their central Suns : so that, Is it not, I say, more than probable, that rest and quiescency is a meer Peripatetrical Notion, and that the supreme Being (who is Activity it self) never made any thing inactive or utterly devoid of Motion ?

Hence wil unavoidable follow some other Principles of the ever-to-be-admired Des-Cartes :

I. That as Matter is made greater or less, by addition or subduction of
c parts,

The Preface.

parts, so is *Motion* made swifter or slower by addition given to the *Mov-vent*, by other contiguous *Bodies* more swiftly moving, or by subduction of it by *Bodies* slower moved.

2. As the parts of *Matter* can be transfer'd from one *Body* to another, and as long as they remain united, would remain so for ever: so *Motion* may be translated from one *Body* to another; but when it is not transfer'd, it would remain in that *Body* for ever.

But these sublime *Speculations* I shall with more confidence treat of in another place; the *Speculation* of *Motion*, and its *Origin*, being, as I
con-

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conceive, one of the obscurest things in Nature.

And therefore at present we shal keep within the compass of the Microscope, and look at nothing further than what we can discover therein: The knowledge of Man (saith the learn'd Verulam) hath hitherto been determin'd by the view or sight, so that whatsoever is invisible, either in respect of the fineness of the Body it self, or the smalness of the parts, or of the subtilty of its motion, is little enquired; and yet these be the things that govern Nature principally: How much therefore are we oblig'd to mo-

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dern Industry, that of late hath discover'd this advantageous Artifice of Glasses, and furnish'd our necessities with such artificial Eyes, that now neither the fineness of the Body, nor the smalness of the parts, nor the subtilty of its motion, can secure them from our discovery? And indeed, if the Dioptricks further prevail, and that darling Art could but perform what the Theorists in Conical sections demonstrate, we might hope, ere long, to see the Magnetical Effluvia of the Loadstone, the Solary Atoms of light (or globuli ætherei of the renowned Des-Cartes) the springy particles

The Preface.

cles of *Air*, the constant and tumultu-
ary motion of the *Atoms* of all fluid
Bodies, and those infinite, insensible
Corpuscles (which daily produce those
prodigious (though common) effects
amongst us:) And though these hopes
be vastly hyperbolical, yet who can
tel how far *Mechanical Industry* may
prevail; for the process of *Art* is inde-
finite, and who can set a non-ultra
to her endeavours? I am sure, if we
look backwards at what the *Diop-*
triks hath already perform'd, we can-
not but conclude such *Prognosticks*
to be within the circle of possibilities,
and perhaps not out of the reach of
futu-

The Preface.

futurity to exhibit: however this I am sure of, That without some such Mechanical assistance, our best Philosophers will but prove empty Conjecturalists, and their profoundest Speculations herein, but gloss'd outside Fallacies; like our Stage-scenes, or Perspectives, that shew things inwards, when they are but superficial paintings.

Boyle
his Es-
says,
pag. 10.

For, to conclude with that doubly Honourable (both for his parts and parentage) M^r. Boyle, When a Writer, saith he, acquaints me onely with his own thoughts or conjectures, without enriching his discourse with
any

The Preface.

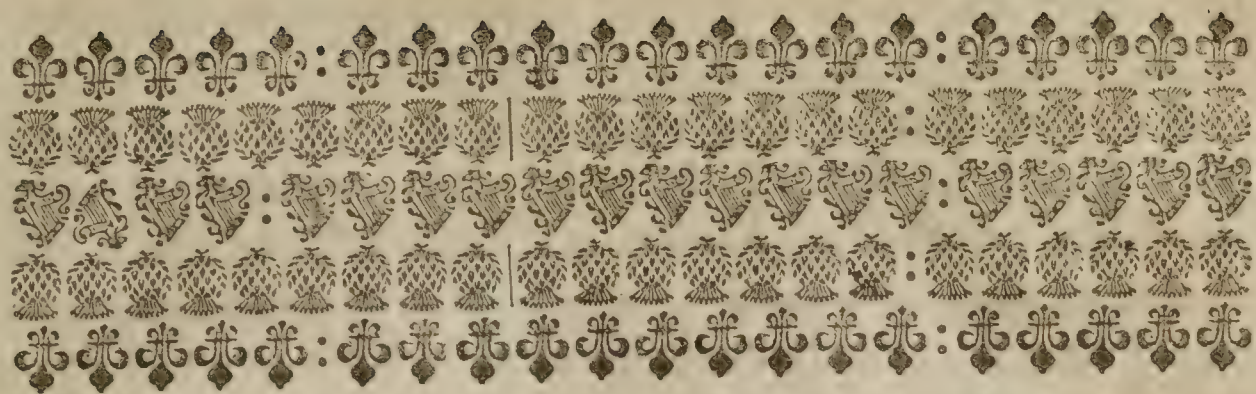
any real Experiment or Observation, if he be mistaken in his Ratiotination, I am in some danger of erring with him, and at least am like to lose my time, without receiving any valuable compensation for so great a loss: But if a Writer endeavours, by delivering new and real Observations or Experiments, to credit his Opinions, the Case is much otherwayes; for, let his Opinions be never so false (his Experiments being true) I am not oblig'd to believe the former, and am left at my liberty to benefit my self by the latter: And though he have erroneously superstructed upon his Experi-

The Preface.

periments, yet the Foundation being solid, a more wary Builder may be very much further'd by it, in the erection of a more judicious and consistent Fabrick.

HENRY POWER.

*From New-Hall,
near Hallifax,
1. Aug. 1661.*



MICROSCOPICAL OBSERVATIONS.

OBSERVAT. I.

Of the Flea.



IT seems as big as a little Prawn or Shrimp, with a small head, but in it two fair eyes globular and prominent of the circumference of a spangle; in the midst of which you might (through the diaphanous Cornea) see a round blackish spot, which is the pupil or apple of the eye, beset round with a greenish glistering circle, which is the Iris, (as vibrissant and glorious as a Cats eye) most admirable to behold.

How critical is Nature in all her works! that to so small and contemptible an Animal hath given such an

B

exquisite

Microscopical Observations.

exquisite fabrick of the eye, even to the distinction of parts.

Had our famous *Muffet* but seen them, he would not have spoke so doubtfully as he did: *Oculos* (saith he, speaking of Flea's) *habere, verisimile est, tum quod suos eligunt recessus, tum quod appetente luce se subducunt.* He has also a very long neck, jemmar'd like the tail of a Lobstar, which he could nimbly move any way; his head, body, and limbs also, be all of blackish armour-work, shining and polished with jemmar's, most excellently contrived for the nimble motion of all the parts: nature having armed him thus. *Cap-a-pe* like a Curiazier in warr, that he might not be hurt by the great leaps he takes; to which purpose also he hath so excellent an eye, the better to look before he leap: to which add this advantageous contrivance of the joynts of his hinder legs which bend backwards towards his belly, and the knees or flexure of his fore-legs forwards (as in most quadrupeds) that he might thereby take a better rise when he leaps. His feet are slit into claws or talons, that he might the better stick to what he lights upon: he hath also two pointers before which grow out of the forehead, by which he tryes and feels all objects, whether they be edible or no. His neck, body, and limbs are also all beset with hairs and bristles, like so many Turnpikes, as if his armour was palyfado'd about by them. At his snout is fixed a Proboscis, or hollow trunk or probe, by which he both punches the skin, and sucks the blood through it, leaving that central spot in the middle of the Flea-biting, where the probe entred.

One would wonder at the great strength lodged in so small a Receptacle, and that he is not able onely to carry his whole armour about him, but will frisk and curvet so

so nimbly with it: Stick a large brass pin through his
 tayl and he will readily drag it away. I have seen a chain
 of gold (at *Tredescants* famous reconditory of Novelties)
 of three hundred links, though not above an inch long,
 both fastned to, and drawn away by a Flea. Such a like
 one it seems as our *Muffet* tells that one *Marcus* an Eng-
 lish-man made. Nay hear what he saith further, *Accepi-* *Muffet,*
mus item à fide dignis, Pulicem sic Catena alligatum, Currum de Inse-
aureum perfectè suis numeris absolutum, nullo negotio traxisse, Etis, lib. 2
id quod & Artificis industriam & suas ipsius vires multum com- *cap. 28.*
mendat: Yea, we have heard it credibly reported, saith
 he, that a Flea hath not onely drawn a gold Chain, but a
 golden Charriot also with all its harness and accoutre-
 ments fixed to it, which did excellently set forth the Ar-
 tifice of the Maker, and Strength of the Drawer: so
 great is the mechanick power which Providence has
 immur'd within these living walls of Jet.

OBSERVAT. II.

The Bee.

THE eye of a Bee is of a protuberant oval figure,
 black and all foraminulous, drill'd full of innumera-
 ble holes like a Grater or Thimble: and, which is more
 wonderful, we could plainly see, that the holes were all
 of a square figure like an honey-comb, and stuck full of
 small hairs (like the pores in our skin) and which (by
 blowing upon) you might see waft to and fro; all which
 neat particularities were more palpably discovered in the
 eye of a great Humble-Bee. Now these holes were not
 absolute perforations, but onely dimples in their crusta-

Microscopical Observations.

aceous *Tunica Cornea*; which it seems is full of little pitholes, like the cap of a thimble: for we cutt out the eye in a large Humble-Bee and Crecket, and bared the shell or horney coat of the eye; and laying either the convex or concave side upwards (upon the object plate) I could easily perceive the little holes or dimples formerly mentioned. So that, by the favour of our *Microscope*, I have seen more in one hour then that famous Bee-master *Aristomachus* did in his fifty years contemplation of those Laborious Insects.

If you divide the Bee (or Humble-Bee especially) near the neck, you shall, without help of the glasse, see the heart beat most lively, which is a white pulsing vesicle. The stings in all Bees are hollow and tubulous (like a Shoemaker's-punch) so that when they prick the flesh, they do also, through that channel, transfuse the poyson into it: For if you take a Bee, Wasp, or Humble-Bee especially, and gently squeeze her tayl, so that you may see the sting, you shall perceive a drop of diaphanous liquor at the very end of it, which if you wipe off, you shall distinctly see it renewed again, that humour passing down the Cavity into the end thereof. But if you would see their Common wealth, Laws, Customs, Military Discipline, and their skill in Tacticks and Architecture, then read our English *Butler*, an experimental and not Theoretical writer on that subject.

OBSERVAT. III.

The Common Fly.

IT is a very pleasant Insect to behold: her body is as it were from head to tayl studded with silver and black Armour,

Armour, stuck all over with great black Bristles, like Porcupine quills, set all in parallel order, with their ends pointing all towards the tayl; her wings look like a Sea-fan with black thick ribs or fibers, dispers'd and branch'd through them, which are webb'd between with a thin membrane or film, like a slice of Muscovy-glasse: She hath a small head which she can move or turn any way: She hath six legs, but goes onely but upon four; the two foremost she makes use of instead of hands, with which you may often see her wipe her mouth and nose, and take up any thing to eat. The other four legs are cloven and arm'd with little clea's or tallons (like a Catamount) by which she layes hold on the rugosities and asperities of all bodies she walks over, even to the supportance of her self, though with her back downwards and perpendicularly invers'd to the Horizon. To which purpose also the wisdom of Nature hath endued her with another singular Artifice, and that is a fuzzy kinde of substance like little sponges, with which she hath lined the soles of her feet, which substance is always repleated with a whitish viscous liquor, which she can at pleasure squeeze out, and so fodder and be-glew her self to the plain she walks on, which otherways her gravity would hinder (were it not for this contrivance) especially when she walks in those inverted positions.

But of all things her eyes are most remarkable, being exceeding large, ovally protuberant and most neatly dimpled with innumerable little cavities like a small grater or thimble, through which seeming perforations you may see a faint reddish colour (which is the blood in the eyes, for if you prick a pin through the eye, you shall finde more blood there, then in all the rest of her body.) The like foraminulous perforations or trelliced eyes are

in

in all Flyes, more conspicuously in Carnivorous or Flesh-Flyes, in the Stercorary or Yellow Flyes that feed upon Cow-dung: The like eyes I have also found in divers other Insects, as the Shepherd-flye or Spinster-flye, which *Muffet* calls *Opilionem Muscam*; also in *Cantharides* or French-Flyes; also in all sorts of Scarabees, black and spotted; also in all sorts of Moth-flyes, called by *Muffet*, *Phalænæ-papiliones*; also in the May-Fly, Butter-flyes, Scorpion-tail'd-fly, Twinges, and Earwigs; most clearly in the floe-black eye of the Creeper, and in the large eye of the Dragon-fly or Adderbolt. Many more observables there are in Common Flyes, as their Vivacity; for, when they appear desperate and quite forsaken of their forms, by virtue of the Sun or warm ashes they will be revoked into life, and perform its functions again.

Had *Domitian* thus busied himself in the Contemplation of this Animal, it had been an employment, not sometimes unworthy of *Cæsar*. For, to conclude with *Muffet*; *lib. de In-* *Dei verò virtutem quàm validè animalcula ista, parùm sanè*
sectis, *valida, demonstrant? Contemplare enim vel minimum musci-*
cap. 12. *lionem, & quomodò in Tantillo Corpore, pedes, alas, oculos, pro-*
muscidem, aliaque membra, omni filo minora, concinnè adapta-
vit Altissimus, ediffere!

OBSERVAT. IV.

The Gray, or Horse-Fly.

HER eye is an incomparable pleasant spectacle: 'tis of a semisphæroidal figure; black and waved, or rather indented all over with a pure Emerauld-green, so that

that it looks like green silk Irish-stitch, drawn upon a black ground, and all latticed or chequered with dimples like Common Flyes, which makes the Indentures look more pleasantly : Her body looks like silver in frost-work, onely fring'd all over with white silk : Her legs all joynted and knotted like the plant call'd *Equisetum* or Horse-tayl, and all hairy and slit at the ends into two toes, both which are lined with two white sponges or fuzballs as is pre-observ'd in Common Flyes. After her head is cut off, you shall most fairly see (just at the setting on of her neck) a pulsing particle (which certainly is the heart) to beat for half an hour most orderly and neatly through the skin.

OBSERVAT. V.

The Butter-Fly.

THIS Animal might well deserve our Observation without the assistance of a *Microscope* ; for who does not admire the variegated diversity of colours in her expanded wings ? which do not onely out-vye the Peacock in all his pride, but does as far out-go the strip'd bravery of the Tulip, as that did *Solomon* in all his glory : But view them in the *Microscope*, and you may see the very streaks of the Cœlestial pencil that drew them. For the wings of the Butterfly seem like a great plume of feathers, with a glystering splendour exceeding pleasant to behold, especially if the wings be strip'd with several colours : yea that small meal and dust of their wings (which sticks to your fingers when you catch them) is all small little feathers, which grow out of
their

* Dr.
Brown
in his
Vulgar
Errors.

their wings; and you may plainly see the twills by which they stick to the wings, and the holes in the wings, out of which they were pluck'd. Nature having imp'd her wings (for her better flight) with those plumeous excrescences; which shews how vastly * they were mistaken, that held this mealy dust to be an exudation of atoms out of their wings.

Her eye is large and globular (but somewhat flattish) white like Alabaster, diced or bespeck'd here and there with black spots (like checker'd Marble) all foraminous, both the white and black parts of it. I mean in a white Butterfly, for in a red-wing'd Butterfly, her eye is all black and full of perforations as in a Common Fly.

The Probe (which you see lyes in her mouth in spiral contorsions, wound up like a spring, or like the twining tendrils of the Vine, and which you may with a pin draw out to its full length) seems to be hollow, and supplies the office both of Mouth and Tongue: for you shall see it (if cutt out and laid on the object-plate) to winde and coyl it self up like a Spring, and then open again a long time together, and to have a transparent kinde of hollownesse quite throughout. Nature having made it of a considerable length (when extended) that she might reach her nourishment, else the length of her legs would hinder the stooping of her head: She hath also fitted it with that spiral or cochleary contrivance, that so being drawn up into an Helix, and retracted into the mouth, it might be no hinderance to her flight.

OBSERVAT. VI.

A Louse.

She appears the bignesse of a large Creet, the body diaphanous and transparent, with three legs on either side, and two horns in the snout, all transparent and of Gauntlet-work, having here and there hairs and bristles; her feet likewise are slit into toes. Her two eyes were like two black beads, gogled and protuberant, standing somewhat backwards on the side of her head behind her horns: She is blackish about the shoulders; if she be laid on her back, you may perceive her body to be of Escallop'd protuberances, diaphanous also, very handsome to behold. In this supine position of hers, there are two bloody darkish spots discernable, the greater in the midst of her body, and the lesser towards her tayl. In the Centre of the middle spot there is a white Film or Bladder, which continually contracts and dilates its self upwards and downwards from the head towards the tayl; and alwayes after every pulse of this white particle or vesicle, then followes the pulse of the great dark bloody spot, in which, or over which, the vesicle seems to swim. This we observ'd two or three hours together, as long as the Louse lived; and this motion of *Systole* and *Diastole* is most palpably seen, when the Louse grows feeble and weak. I prick'd the white vesicle with a small needle and let out a little drop of blood; and then viewing her again in the *Microscope*, we could not perceive any life or motion after.

In a greater Louse you might see this pulsation of
C her

her heart through her back also; but the white film or vesicle you cannot see till she be turn'd with her belly upwards.

The lower dark spot (which is the lesser towards the tayl) Dr. *Harvey* probably conjectures to be the excrements in the guts of the Louse, there repositied just before exclusion.

In Epi-
stolâ
dedica-
toriâ,
Muffeti
de Inse-
ctis.

Hear how neatly Sir *Theodore Mayhern* delivers his Observation of this Animal, taken in a puny Microscope; *Pediculorum oculos prominentes (Ope Conspicilii) cernes, & Cornua, & Crenatum Corporis Ambitum, totam substantiam Diaphanam, per quam Cordis & Sanguinis tanquam in Euripo indefinenter fluctuantis Motum.*

OBSERVAT. VII.

A Wood-Louse, or Wood-Mite.

THere is a little white Animal (which you shall finde usually running over the leaves and covers of books, and in rotten wood) which in Shape and Colour is like a Louse, onely it has a swift motion, and runs by starts or stages; you may kill it with a very little touch with your finger: This Animal being fastened to the object-plate, by a little spattle, looks like polish'd silver, her whole body cas'd in Annulary circles, all full of silver hairs, especially towards her tayl, with six legs, three on each side, whose extremities are arm'd with two black tallons, which you might see to move distinctly of themselves: Two long moveable horns were fastened to her head, but revers'd and pointing backwards towards her tayl, with little branches and twigs (like

(like Bezanteliers) springing out of them. She hath two pointers also before, like a pair of pincers, which she moved laterally, all full of hairs, and two round knobs at the ends of them. Her eyes are very protuberant, and globular, of a pure golden colour, most admirable to behold, especially when varnish'd with a full light, and most neatly latticed or matted like a net (as hath been pre-observ'd in other Insects.) And she seem'd to have this peculiar Artifice, that she can put out or draw in her eye at her pleasure; so that sometimes we could see them far more prominent then at others; and sometimes again the one eye more then the other: In-
somuch that in one of our Critical Observations, I could see more then a hemisphere of the eye at once; so that what the *Processus Ciliares* does to our eyes, either in retracting or protruding the Crystalline Humour (for helping the sight) the same does the Optick nerve (it seems) to the whole Globe or Bulb of their eyes.

OBSERVAT. VIII.

The House-Spider.

NOW let us see what we can discover in *Ovid's* *Lydian-Spinstresse*, that proud Madam which *Pallas*, for her Rivalship, transform'd into the Spider; which hath not onely the Character of *Aristotle*, but of *Solomon* himself, for a wise and prudent Animal, and therefore a fit Residentiary in the Court of Kings.

Of Domestick Spiders there are two sorts; one with longer legs and a little body, and the other contrariwise.

The first eminent thing we found in these House-Spi-

ders, were their eyes, which in some were four, in some six, and in some eight, according to the proportion of their bulk, and longity of their legs. These eyes are placed all in the forefront of their head (which is round, and without any neck) all diaphanous and transparent, like a Locket of Diamonds, or a Sett of round Crystal-Beads: so that well might *Muffet* say of those Philosophers that held them blinde, *Sanè cæcutiunt illi summo meridie, qui videre ipsas non vident neque intelligunt*: Far better might he have said it, if his eyes had had the assistance of our *Microscope*.

Neither wonder, why Providence should be so Anomalous in this Animal more then in any other we know of (*Argus* his head being fix'd to *Arachne's* shoulders.) For, first: Since they wanting a neck cannot move their head, it is requisite that defect should be supplied by the multiplicity of eyes. Secondly: Since they were to live by catching so nimble a prey as a Fly is, they ought to see her every way, and to take her *per saltum* (as they do) without any motion of their head to discover her; which motion would have scar'd away so timorous an Insect.

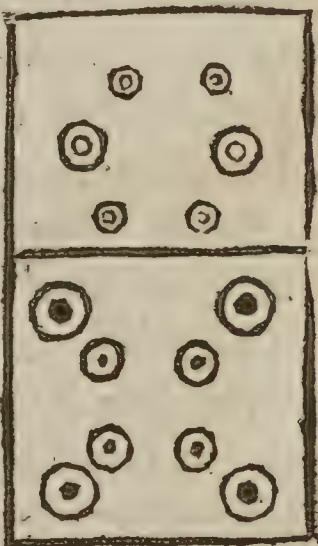
They have a very puffy light body of an Oval figure, covered with a sleek thin skin: which they change once a moneth, sayes *Muffet*; though I hardly believe they cast their spoils so often.

Their skin is not pellucid; for I could never discover any pulsing particle within them: She hath eight legs, four on each side, split into small oblong fingers at the ends, by which she makes her curious Web-work. Both body and limbs is all stuck over with small silver hairs, which the very ayr will waft to and fro, as you may see in the *Microscope*.

OBSERVAT. IX.

The little white Field-Spider with short legs.

THere is a little white short-leg'd Spider (which you shall find plentifully amongst new Hey, or in a sweating Hey-mough) which is a glorious spectacle to behold ; for her Body is like white Amber imboss'd all over with black Knobs, out of every one of which grow bristles or prickles like whin-pricks perfectly taper-grown. And (which is most admirable) we could most distinctly see six, in some eight eyes, ranged in this order ; the innermost least, and the outermost greatest, of a very quick and lively transparency or fulgour, like Eagle's eyes ; every Eye hath a pale yellow circle, which encompasseth a violet-blew Pupill, most clear and most admirable, but not perforated at all.



Letting her lye on the object-plate for half an hour together, we perceived her Eyes all of them to grow less and less, and a whitish kind of film or socket, by degrees, to cover part of them : I cutt her in the midst at first, and so layd onely her head with the upper part of her body, on the object-plate.

OBSERVAT. X.

The Field Spider with long Legs.

THis Spider was a very pleasant spectacle: having cutt off her legs, and layd her flat with her belly upon the object-plate, I perceived a round knob erected perpendicularly upon the top of her back, which proved to be her head (though at first I could not perswade my self into that belief;) for in it were fixed two jett-black protuberant (but not foraminulous) eyes, on either side one, which by diligent Inspection we found to be of different parts, with a very black smooth pupil in the midst of either of them, more protuberant than the rest of the circumambient matter, which was of a coarser grain, browner and more rugged than the prominent Pupil.

She had before, two claws (at a manifest distance from her head) just like a Crab's claws, with two black tips, like the Chely's in Crabs, which I could distinctly see to open and shutt (exactly like those in a Scorpion) which were indented, or made Saw-wise on the inside (the better to keep fast what she had once laid hold on.)

There is a Field-Spider of a russet colour and long legs, of the same shape and figure.

The head and eyes in all Spiders are contrived with great variety.

OBSERVAT. XI.

Another Field-Spider.

I Took a Field-Spider under a stone, 13. of June, with a bag of eggs fastned to her tayl, bigger than all the bulk of her body ; I opened it, and saw abundance of blewish eggs in it, which in the *Microscope* look'd white and round, like your counterfeit pearl, and I could most clearly see abundance of very minute Spiders, newly hatch'd, no bigger, and just like Mites in Meal, with white hairs and bristles, especially in their tail, creeping and crawling amongst the eggs : The Nett-work of the Purse or Bag seem'd all diaphanous ; a very pleasant spectacle, and of curious workmanship.

I then made the like Observation of a bag full of House-Spider-eggs, which are round and white, just like white Poppy seed ; and all things look'd whitish, and something Transparent therein also : but the youngling Spiders (that were either hatching, or newly hatch'd) were far bigger then the former, and white as Alabaster, but shap'd like the Parent with five legs on each side (without hairs or bristles) and not by far so active as the other. I could not see any Heart beat in any of them all.

OBSERVAT. XII.

Mites in Cheese.

They appeared some bigger, some less ; the biggest appeared equal to a Nutmeg ; in shape they seem'd oval and obtus'd towards the tail : Their colour resembled that of Mother of pearl, or Common pearl, and reflected the light of the Sun in some one point, according to their various positions, as pearl doth : so that it seems they are sheath'd and crustaceous Animals (as Scarabees and such like Insects are.) I could perfectly see the divisions of the head, neck, and body. To the small end of the oval Body was fastned the head, very little in proportion to the body, its mouth like that of a Mole, which it open'd and shutt ; when open'd, it appear'd red within : The eyes also, like two little dark spots, are discernable : Near to the head were four legs fastned, two on each side ; the legs were just like to those in a Louse, Jemmar'd and Transparent : She has two little pointers at the snout ; nay, you may see them sometimes, if you happily take the advantage, like so many *Ginny-Pigs*, munching and chewing the cud : About the head and tail are stuck long hairs or bristles : Some we could see (as little, even in the Glasse, as a Mustard-seed) yet perfectly shap'd and organiz'd : We also saw divers Atoms somewhat Transparent like eggs, both in form and figure. Nay, in these moving Atoms, I could not onely see the long bristles formerly specified, but also the very hairs which grew out of their leggs, which leggs themselves are smaller than the smallest hair

hair our naked eyes can discover. What rare Considerations might an Ingenious Speculator take up here, even from this singular Experiment? of the strange and most prodigious skilfulness of Nature in the fabrick of so Minute an Animal (a thousand whereof do not weigh one single grain, (for one seed of Tobacco is bigger than any of them) and yet how many thousand parts of Matter must go to make up this heterogeneous Contexture? For, besides the parts intervient to Nutrition, Sensation, and Motion, how small and thin must the liquours be that circulate through the pipes and vessels disseminated through those parts? nay, How incomprehensibly subtil must the Animal-spirits be, that run to and fro in Nerves included in such prodigiously little spindle-shank'd leggs?

OBSERVAT. XIII.

Mites in Malt-dust and Oatmeal-dust.

They seem somewhat different from those of Cheese, formerly described, yet of the same bulk, proportion, and colour; onely besett with more and longer white bristles, especially in the tail: they are far more active and quick in motion than those Inhabitants of *Cheese-Bobby*, some bigger, some lesser. Some we saw so exceeding little (yet perfectly organiz'd and shap'd like the rest) that no bristles nor hairs could be discern'd, either because they had none, or else (more probably) because the Glass failed in presenting them: for how small must that hair be, think you, which (though so excessively augmented in the Glass) yet seems as small as
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any hair imaginable ? and upon an Animal too, whose whole bulk to the bare eye is quite indiscernable.

If you besprinkle the Object-plate, upon which you view them, with a pretty quantity of Oatmeal, you shall see what working and tugging these poor little Animals make amongst it, running and scudding amongst it ; under it, over it, and into it, like Rabbits into their Burrows ; and sometimes casting it and heaving it up, (as Moles or Pioners do earth) and trolling to and fro with this mealy dust (which seems something diaphanous) sticking to them, as if it were a little world of Animals, busying themselves in running this way and that way, and over one anothers backs ; which is a spectacle very pleasant to behold.

OBSERVAT. XIV.

Mites, bred amongst Figs.

They are in colour like other Mites, but bodyed and shaped like Scarabees, with two little short horns at the snout, and above them two very long ones : you may clearly see three leggs on either side the body : they are more sluggish and unweildy then Meal-mites are, and not bristled like them. Though I have seen some amongst them also full of white bristles, and shaped like those in Oatmeal: the like common (for so I may call them) Mites I have also found in Hay, in the powder that falls off dried roots, &c.

OBSERVAT. XV.

The Mites, in Fujubes and Sebesten's.

FROM Jejub's and Sebesten's, being long kept, there falls a brownish kind of powder, which being laid upon the Object-plate, you shall discover in it small whitish Mites, very little ones, and all besett with bristles and hairs round over like a Hedghog, but not of so quick and lively a motion as the other Mites.

OBSERVAT. XVI.

The red Mite, found on Spiders.

THERE is a red Mite which you shall often find feeding upon Spiders; She is bodied just like a Tortoise, with a little head and six long small leggs, three on each side: About the leggs of the Field-Spider I have found many of these Coral-Mites or Tortoises, and this thing I have observed of them, That they cling exceeding close to the Animal whilst she is alive; but when dead, they all fall off and creep away from her, as lice do from dying men, or other vermin from an old rotten falling house.

OBSERVAT. XVII.

The Mites or Lice found on Humble-Bees.

Within that yellow plush or furre of Humble-Bees you shall often find a little whitish very nimbly-running Animal, which hath the shape and form of a Mite in the *Microscope*: I remember the Industrious *Kircher* sayes, he hath found by his Glasses Lice upon Fleas: Either our Fleas in *England* are not like theirs in *Italy* for this property, or else I have never taken them in their Lowlie season: But I see no reason to the contrary, but both Fleas and Lice may have other Lice that feed upon them, as they do upon us. For since the minutest Animal that comes within the reach of our *Microscope*, is found to have a mouth, stomach, and gutts, for Nutrition; and most, if not all, the *Parenchymata* for Circulation and Separation of Excrements, there can be no doubt, but they have also a continual perspiration and exudation through the habit of their body: Of which excrement of the third and last Concoction, all these Vermin that pester the outside of Animals, are generated.

OBSERVAT. XVIII.

Pond Mites.

THere are bred in most restagnant Waters, Pools and Fishponds, in *June* and *July*, an innumerable company

ny of little whitish Animals, which move up and down the water with jerks and stops in their motion; in which Animals we could discover two little horns and leggs, but could never get to see it quick in the *Microscope*: for as soon as ever it is taken out of the water, it is perfectly dead. Neither may it seem strange to find these Animals in restagnant fish-waters, since the very Ocean it self in some places (in summer time) is full of Living creatures. For our western Navigators tell us, That in summer, in the West-Indian Seas (about the Coasts of *Virginia*, *Hispaniola*, *Jaimaca*, *Cuba*, &c. the Sea swarms with Maggots and Grubs, which in a little time will so eat their very ships (as far as they draw water) that lye there at Anchor, that they will be as brittle and as full of holes as a honey-comb, or a grater; insomuch that we are forced to have them cased either with thin sheets of Lead, or with Flax, Pitch and Tarr, to secure them from that danger.

Nay, not onely the Water, but the very Air it self, may certainly at some times and seasons be full of Living creatures; which must be, most probably, when great putrefactions reign therein, as in the Plague-time especially.

Now it were well worth the Observation, if in such aerial Putrefactions any kind of Living creatures could be discovered, which probably may be done by Glasses: for I am sure in my long *Telescope* I can some days see a tremulous Motion and Agitation of rowling fumes, and strange Atoms in the air, which I cannot see of other days; of which I shall perchance more largely discourse in my *Telescopical Observations*.

OBSERVAT. XIX.

*Whey-worms, call'd by some, Wheal-worms,
or Hand-worms, or Barrows.*

THESE smallest of Creatures (being accounted by *Muffet* as a Species and kind of Mites, bred upon Animals, as the former sort are in Cheese, Meal, Wax, rotten Wood, &c.) may very well be the subject of our next Observation.

In this small Animal you may see an oval reddish head, and therein a mouth or prominent snout, arm'd with an Appendent Proboscis or Trunk, consisting of many villous filaments in figure of a Cone, wherewith it perforates our skin, and sucks the blood or Aqueous nutriment from the pustules it is bred near. Nay, you may discover feet, laterally ranged on both sides, and many hairy tufts on the tayl, with asperities, rugosities, and protuberances in the skin. To behold all which varieties of parts and organs in so minute a particle of Matter (as this living Atom is), I know not whether it be more admirable to behold, or incredible to believe without an Ocular Demonstration.

Certainly *Scaliger* and *Muffet* would have far more admired this almost invisible sub-cutaneous Inhabitant, had they had the happiness to have seen it in our *Microscope*. Hear their description, taken onely by the Opticks of Nature, *Syronibus nulla expressa forma, præterquam glabris vix oculis capitur; magnitudo est tam pusilla, ut non atomis constare ipsum sed unum esse ex Atomis Epicurus dixerit: ita*
Muffet, Cap. 24. de Insect. lib. 2. sub

sub cute habitat, ut, actis cuniculis, pruritus maximum loco ingenerat, præcipuè manibus: extractus acu, & super ungue positus, movet se, si Solis etiam calore adjuvetur. Mirum est quomodo tam pusilla Bestiola, nullis quasi pedibus insidens, tam longos sub Cuticula sulcos peragat.

Our famous Mayhern (who had the advantage of an Ordinary Microscope) gives this short, but very neat description of this poor Animal. *Imò ipsi Acari, (saith he) præ exiguitate indivisibiles, ex cuniculis prope aquæ lacum, quos foderunt in cute, acu extracti & ungue impositi, caput rubrum, & pedes quibus gradiuntur, ad solem produunt.* And therefore it is not to tell in what a small particle of Matter, life may actually consist, and exercise all the functions too, both of Vegetation, Sensation, and Motion: So that, *Omnia sunt Animarum plena*, may have more of truth in it, than he could either think or dream of that first pronounced it.

In Epi-
Prafato-
riâ, ad
Muffet.
de Inse-
ctis.

OBSERVAT. XX.

The Gloworm or Glassworm.

HER Eyes (which are two small black points or specks of jett) are pent-hous'd under the broad flat cap or plate which covers her head; which obscure situation, together with their exceeding exiguity, make them undiscernable to common Spectators. Yet in the Microscope they appear very fair, like black polish'd jett or marble, semi-globular, and all foraminulous, or full of small but very curious perforations (as in Common Flyes.) Her two horns are all joynted and degree'd like the stops in the germination of some Plants, as

Hors.

Microscopical Observations.

Horf-tail and Canes : Under which she hath two other small horns or pointers, of the same stuff and fashion. Take hold of her horns, and you may draw out her eyes and cut them out, and so lay them on your object-plate and see them distinctly. This is that Night-Animal with its Lanthorn in its tail; that creeping-Star, which seems to outshine those of the Firmament, and to outvie them too in this property especially; that whereas the Coelestial Lights are quite obscured by the interposition of a small cloud, this Terrestrial-Star is more enliven'd and enkindled thereby, whose pleasant fulgour no darkness is able to eclipse.

OBSERVAT. XXI.

Common Grasshoppers.

IN those Common Grasshoppers, both great and little, which are so frequent at hay-time with us, there are some things remarkable. First, Their Eyes, which like other Insects are foraminulous; nay, we have taken the Cornea or outward Film of the Eye quite off, and clenf-ed it so from all the pulpous matter which lay within it, that it was clear and diaphanous like a thin film of Sliffe or Muscovy-glass, and then looking again on it in the *Microscope*, I could plainly see it foraminulous as before.

You shall in all Grasshoppers see a green Film or Plate (like a Corflet) which goes over the neck and shoulders, which if you lift up with a pin, you may see their heart play, and beat very orderly for a long time together.

The

The like curious Lattice-work I have also observ'd in the crustaceous *Cornea* of the Creckets Eye, which I have carefully separated from all the matter which stuff'd it within, which certainly is their Brain; as hereafter shall be made more probable.

OBSERVAT. XXII.

The Ant, Emmet or Pismire.

THis little Animal is that great Pattern of Industry and Frugality: To this Schoolmaster did *Solomon* send his Sluggard, who in those virtues not onely excels all Insects, but most men. Other excellent Observables there are in so small a fabrick: As the *Herculean* strength of its body, that it is able to carry its triple weight and bulk: The Agility of its limbs, that it runs so swiftly: The equality of its Motion, that it trips so nimbly away without any saliency or leaping, without any fits or starts in its Progression. Her head is large and globular, with a prominent Snout: her eye is of a very fair black colour, round, globular, and prominent, of the bigness of a Pea, foraminulous and latticed like that of other Insects: her mouth (in which you may see something to move) is arm'd with a pair of pincers, which move laterally, and are indented on the inside like a Saw, by which she bites, and better holds her prey; and you may often see them carry their white oblong eggs in them for better security.

OBSERVAT. XXIII.

Of the little greenish Grasshopper or Locust, bred upon the backside of green leaves, especially the leaves of Gooseberries, Sweet briar, and golden Mousse-ear, in April and beginning of May.

THis pretty Animal is a pleasant Object to look upon in our Glass, being of a light Green, and in the full Sunshine shews exactly like green Cloth of Silver; hath two horns and four leggs, two on each side: Her eyes are two such very little black Atoms, that, unless to a very critical and smart eye, they are indiscernable; yet, if you advantageously place her, and view her with a full light (transmitted through a Burning-glass (which artifice I sometimes use) you shall fairly see them to be as bigg as two small black round Beads, and drill'd through also with innumerable perforations (as the eye in a Fly) which will try the exquisiteness both of your Glass and Eye to behold.

OBSERVAT. XXIV.

The yellow Locust.

THere is a pretty, but very little, white oblong Insect, which sticks to the ribs and backside of Rose-tree.

tree-leaves in *August*, which in the *Microscope* looks of a pure white colour, and diaphanous like Sugar-Candy, with an Annular body like a Wasp, with some eight hoops or rims, and conical or rush grown towards the tayl, with six long legs, every leg composed of three joynts, all besett with short hairs, especially in the Annular divisions and Interstices of her body: Her eyes were very globular, protuberant, and large (as they are in all young Animals) white, like two crystal Beads, and most neatly lattic'd, which I could most clearly discern.

Below the eyes (as she lay upon her belly) was two crook'd horns, which bended backwards towards her tayl, and was fasten'd in two sockets at the roots; and, as I thought, I sometimes see her eyes more protuberant than others, as if she could thrust them out, and draw them in at pleasure, as we have formerly observ'd in the Wood-Louse *Observ.* 7 She has two pair of Bristles or hairs (like Mustacho's) at the Snout, one bending one way; and another, another. I could discover no Mouth, though I turn'd her over and over. This puny Insect I have observ'd to turn into a small yellow Locust, with two white wings longer than the body, and to skip up and down the Rose-tree-leaves in *August*; and then (when she was metamorphos'd into a Locust) I could discern no Mouth in the *Microscope*, but onely two pointers like a pair of closed Compasses in her Snout, which cannot be seen on her till she be winged, and then laid on the object-plate with her belly upwards.

OBSERVAT. XXV.

Of Cuckow-Spitt, and the little Insect bred therein, in May.

THat spumeous froth or dew (which here in the North we call Cuckow-Spittle, and, in the South, Wood-sear; and which is most frequently found in Lavander-Beds, Horf-mint, &c.) looks like a heap of glass-bubbles, or a knob'd drinking-glass; in which you shall always find a little Grub, or Animal, which in the *Microscope* seems a pretty golden-coloured Insect, with three leggs on each side; and two horns, and two round fair goggle-eyes of a dusky red colour, like polish'd Rubies; which you may also see latticed and perforated in a clear light. Her tayl is all jemmar'd with Annulary divisions, which at last end in a stump, which she often draws up, or thrusts out, at her pleasure.

Muffet, *de Insect.* *Muffet* calls this Insect, *Locustellam*, or, a puny-Locust; and saith, That first it creepeth, then leapeth, and at last flyeth. She has two blackish claws, or pounces (at the ends of her feet,) which she can open and shut at her pleasure: We could discover no mouth at all, but a long reddish Probe, between the fore-legs, through which, perchance, she suck'd her froathy nourishment.

Now, what this spumeous matter is, and into what Animal this Insect is at last shaped or transpeciated, are Doubts that as yet have found no clear and experimental Decision.

That the Spattle is a froathy kind of dew that falls from

from the Air, I doubt not, whatsoever my Lord *Bacon* say to the contrary. For, first; It is found upon most, if not all, Plants whatsoever, but most copiously amongst our *Whinns*, or prickly Broom; and generally about the joynts and ramulous divisions, because there it is best secured from the heat of the Sun, which licks it off the open leaves, or else probably it is imbibed by the full grown and porous leaves of Plants, as the *Mill-dew*, and other honey-Dews are.

Secondly, That it is the sole exudation and secrement of Plants, I cannot believe: First, because it is never found upon their Second growth, nor in *Eddish*: Secondly, How should an excrement of so many several Plants, still breed one and the same Animal, when as we see that all Vegetables whatsoever produce their several Insects (as *Muffet* in his 19. and 20. Chapters has particularly enumerated.) I shall not deny but the Effluvium's that continually perspire out of all Plants whatsoever, may advantage and promote the nutrition of the little Insect that breeds therein.

For that all Vegetables have a constant perspiration, the continual dispersion of their odour makes out; besides an experimental eviction I shall give you by this singular Experiment: 23. of *Feb.* (-.61.) we weighed an *Onyon* exactly to two ounces, two scruples and a half, and hanging it up till the 6. of *May* next following (at which time it had sprouted out a long shoot) we then, upon a re-ponderation of it, had lost near two drams of its former weight, which was exhaled by insensible Transpiration.

OBSERVAT. XXVI.

The Cow-Lady, or Spotted Scarabee.

IT is a very lively and nimble Animal : Cut off the head, and erect it perpendicular upon the neck (which must be fasten'd to a bit of soft Wax) and then you shall see those two little small black eyes it hath, sett upon a little short neck (which is moveable within the former) either eye sett between three white plates, like polish'd Ivory (two little ones on the one side, and one great one on the other) her eyes are also foraminulous, and curiously lattic'd like those in a Fly formerly describ'd. If you unsheath her body, and take off her spotted short crustaceous wings, you shall find under them another pair of filmy Tiffany long wings, like those of Flyes, which lye folded up, and cas'd within the former, of both which pair she makes use in flying; which being removed, nothing remains to secure the bulk of the body but a thintender black skin, under which you might most lively see the pulsation of her Heart for twelve or fourteen hours, after the head and neck was separated.

OBSERVAT. XXVII.

The Water-Insect, or Water-Spider.

THere is a black crustaceous Insect with an Annular body, and six hairy legs, which moves nimbly upon the water; the two foremost legs are shorter than the

the rest by one half, and serve instead of hands to reach any thing to the mouth: She hath two hairy geniculated horns, knotted or joynted at several divisions like Knot-grafs, or Horf-tayl: Her body is like Frost-work in silver: Her eyes black, globular, and foraminulous.

OBSERVAT. XXVIII.

The Wasp-like Locust.

There is a little small long black Insect, which you shall find creeping and leaping amongst Pinks, Gillyflowers, Rose-leaves, &c. which in the *Microscope* hath two fair long wings, and is bodied just like a Wasp (from whence I have given her the name of the *Wasp-Locust*) with six or seven Annulary divisions, of jett-black and yellow wings: She hath two horns, made of five or six white and black internodium's, very pretty to behold: either of them arising from a black knobb'd root, with three black legs on either side, and two little black eyes, and, as I gheffed, latticed; though, What Art can present distinct parts in that eye which is sett in an Animal so small, that the whole bulk of it is no bigger than a little bit of black thread, or hair. They are kill'd with the least touch imaginable. I took them with a Pins point dipp'd in spattle, and so glew'd them to the object-plate, as I do stronger Insects with a touch of Turpentine.

OBSERVAT. XXIX.

The Sycomore-Locust.

There is a pretty little yellow Insect, which is bred, and feeds on the Sycomore-leaves, which at first hath no wings, but six leggs and two horns, and runs nimbly up and down: In the Glass, I could not onely see its eyes, which are red, globular, goggled and prominent; but also I could see them very perfectly latticed. She had two horns, which at the ends were slit and bi-furcated: I could, near her shoulders, see the stumps of her growing wings: This at last is transpeciated into a Fly with two long wings; or rather a Locust: it consists of Annulary Circles, and has hairs towards the tayl.

OBSERVAT. XXX.

Of the little white Eels or Snigs, in Vineger or Aleger.

They appear like small Silver-Eels, or little Snigs, and some of them as long as my little finger, constantly wrigling and swimming to and fro with a quick, smart, and restless motion. In which smallest of Animals these things are most remarkable:

First, They are not to be found in all sorts of Vineger nor Aleger, but onely in such, probably, as has arrived
to

to some peculiar temper or putrefaction, of which I can give you no Characteristical Signs; for, I have found them in all sorts of Vineger, both in the keenest and smartest, as well as in the weakest and most watrish Vineger; and in all these sorts, you shall sometimes find none at all; and I have both found them, and also vainly sought them, in the former Liquors, at all seasons and times of the year also.

Secondly, The manner and best way of observing them is, upon a plain piece of white glass, whereon two or three drops of the said Liquors are laid; and so laying that glass on the object-plate, and fitting your *Microscope* to it, you may distinctly see them to play and swim in those little Ponds of Vineger (for so big every drop almost seems) to the very brink and banks of their fluid element.

Thirdly, Nay you may see them (especially in old Aleger) with the bare eye, if you put a little of it into a clear *Venice*-glass, especially into those pure thin white bubbles, which they call Essence-glasses; you may then see an infinite company of them swimming at the edges of the Liquor, nay and in the body of it too, like so many shreds of the purest *Dutch* thread, as if the whole Liquor was nothing else but a great shoal or mass of quick Eels or Hair-worms.

I have another advantageous way of discoverance of them to the bare eye also, which is by putting a little of those Liquors into a little cylinder of white glass, of a small bore and length, either sealed or closed up with cork and wax at the one end: therein, if you invert this glass cylinder, and often turn it topsy turvy, no Liquor will fall out, onely a little bubble of aire will always pass and repass through the inverted Liquor, and

one pretty thing I have herein observed, that when this bubble has stood in the superiour end of the glafs (and sometimes it would do so for a pretty while together before it broke) I have seen some of those small Snigs or Animals on the top of it, crawling over the smooth convexity of the bubble (like so many Eels over a Looking-glass) without breaking thorow the tender cuticle and film of so brittle and thin a substance.

Fourthly, That as the Liquor (dropt upon your object-plate) spends and dries up, so you shall see those little Quicks to draw nearer and nearer together, and grow feebler in their motion; and when all the Vineger or Aleger is dried away, then they lie all dead, twisted and complicated all together, like a knot of Eels, and after a little time dry quite away to nothing.

Fifthly, Their heads and tails are smaller then the rest of their bodies; which is best observed by the *Microscope*, when the Liquor wherein they swim is almost spent and dried up, so that their motion thereby is rendred more feeble and weak, or when they lie absolutely dead.

Sixthly, Another remarkable thing, is, their exceeding exiguity; for certainly of all Animals they are the least that can be seen by the bare eye, which is helped and advantaged also by the refraction of the water wherein they swim.

Seventhly, If you take a spoonful of the foresaid Vineger and heat it over a few coals, it presently destroys all the Quick's in it, so that you may see them all stretched out at their full length, like a pencil chopt small, or little bits of hairs swimming up and down the Liquor, which in a short time will precipitate and all sink down to the bottom of the glafs.

Nay these poor Vermin are not onely slain by actual heat, but by a potential one also: for, putting but a few drops of the Oyle of Vitriol into an Essence-glass full of that Vineger, it also shortly destroyed them in the same manner as the fire had done before.

Eighthly, Now though heat hath that killing property, yet it seems that cold hath not: for I have taken a jar-glass full of the said Vineger, and by applying Snow and Salt to it, I have artificially frozen all the said Liquor into a mass of Ice, (wherein all these Animals it seemed lay incrystalled) though I could discover none of them in it (though I have taken the Icy-mass out on purpose to look at it) so that now I gave them for gone for ever: yet when I came again (about two or three hours after) to uncongeal the Liquor, by keeping the glass in my warm hand, when the Vineger was again returned to its former liquidity, all my little Animals made their re-appearance, and danced and frisked about as lively as ever. Nay I have exposed a jar-glass full of this Vineger all night to a keen Frost, and in the morning have thaw'd the Ice again, and these little Vermin have appeared again and endured again that strong and long Conglaciation without any manifest injury done to them; which is both a pretty and a strange Experiment.

Ninthly, I have filled an essence-glass half with the said Vineger, and half with Oyle (which floated on the Vineger) in a distinct Region by it self, and I have observed that in frosty weather when the Vineger has been congealed, that all the little Eels have run up into the super-incumbent oyle to preserve themselves there, and would not return till some warmth was applied to the Vineger again, and then they would al-

ways presently return down into their native Liquor again.

Tenthly, Their motion is very remarkable, which is restless and constant, with perpetual undulations and wavings, like Eels or Snakes; so that it seems, that Animals that come nearest the classis of Plants, have the most restless motions.

Eleventhly, the innumerable number and complicated motion of these minute Animals in Vineger, may very neatly illustrate the Doctrine of the incomparable *Des-Cartes*, touching Fluidity: (*viz.*) That the particles of all fluid bodies are in a continual and restless motion, and therein consists the true nature of fluidity: for by this ocular example, we see there may be an intestine restless motion in a Liquor, notwithstanding that the unassisted eye can discover no such matter, which likewise is evinced by *Observ. 13. Of the Mites in Meal.*

OBSERVAT. XXXI.

Of the great Black Snail.

IN this slimy Animal (the slow-paced Engine of Nature) are very many rare and excellent Observables. The first is his Eyes, which are four in number, (like black atramentous Spots) fixed to the end of their horns; or rather to the ends of those black filaments or optick nerves, which are sheathed in her horns which she can retract or protrude, through the hollow trunk of her horns, as she pleaseth.

If with your finger you take hold of the tip of her
horn

horn when fully extended, and draw out this nervous filament, or then nimbly clip off the extremities of her horns, you shall in the *Microscope* see those 2. black spots to be semi-spherical eyes, like two large blew Beads: and we could afterwards also, when she re-extended the stump, clearly perceive it with the bare eye to be tubulous and hollow. And therefore however, though the learned Doctor *Brown* (my ever honoured friend) hath ranked this conceit of the Eyes of a Snail (and especially their quadruplicity) amongst the Vulgar errors of the multitude; yet through a good *Microscope*, he may easily see his own error, and Nature's most admirable variety in the plurality, paucity, and anomalous Situation of eyes, and the various fabrick and motion of that excellent organ; as our Observations will more particularly inform him.

If by a dextrous Dissection you would see the internal Fabrick of this Animal, there are many excellent things that will recompence your curiosity.

For first, you may find her Heart just over against that round hole near her neck (which Doctor *Harvey* ingeniously conjectures to be the place of their respiration; which hole you may observe to open and shut as she moves or stands still, and out of which I have observed some salivous Matter to be evacuated.

We have observ'd her Heart to beat fairly for a quarter of an hour after her dissection; afterwards we took out her guts which were of a pure green colour, by reason of the thinness of their film, and transparency of the green juice of hearbs with which they were repleated.

They were all diaper'd or branched over with pure white Capillary little veins, which (by help of the *Microscope*)

eroscope) we could discern to be hollow, with a blackish kind of pith running through the midst of the smallest of them, which doubtless was their nutrimental juice coagulated there, like the blood starkn'd in the veins of dead Animals.

They are mouthed like a Hare or Rabbit, with four or six needle-teeth, like those in Leeches.

Nay this poor Animal (how contemptible soever it may seem) hath a whole Sett of the same parts and organs with other Animals, as Heart, Liver, Spleen, Stomach, Guts, Mouth and Teeth, Veins and Arteries: Yea and a pair more of the noblest of the Senses (the Eyes.)

Nay this Animal doth autoptically evince us, that, as sanguineous and more perfect Animals, have a circulation of their blood within them; so this more ignoble creature hath also a circulation of its nutritive humour, which is to it as Blood is to other Animals.

Nay further (which is the best Remarkable of all) this juice hath not onely a circular motion; but also the very Animal Spirits (by which she moves) seem to have the like Circulation. For, if you observe her with the bare eye to creep up the sides of a glass, you shall see a little stream of clouds, channel up her belly from her tail to her head, which never return again the same way, but probably go backwards again from the head down the back to the tail; and thus, so long as she is in local motion they retain their circulation, which is a pleasant spectacle. And more pleasant, if you let her creep upon the lower side of your glass-object-plate, and so view that wavy Current of Spirits through the *Microscope*; which handsome experiment does not onely prove the Spirit's circular motion, but also ocularly demonstrates

strates that the Animal Spirits are the Soul's immediate instrument in all Loco-motion.

Now if you reply that it is onely the parts of her body, that moving by a kind of undulation protrude one another forwards, as Palmer-worms (which we call Wool-boys,) and some sort of Caterpillars do: To this I answer, that do but intently observe any one of the former spots or clouds, and you shall see it go quite along from the tail to the head, keeping alwayes an equal distance from the precedent and subsequent spot: so that it is far more ingenious to believe it to be a gale of Animal Spirits, that, moving from her head along her back to her tail, and thence along her belly to her head again, is the cause of her progressive motion.

OBSERVAT. XXII.

Of Lampreys.

THE Lamprey hath seven holes or cavities, on either side three or four, and no gills at all, as other fishes have; whence the common people, through ignorance of these cavities, and their proper use in nature, have affirmed them to be Eyes; an error so gross and palpable, that it needs not the *Microscope* to refute it: For these holes or fluces do indeed supply the defect of gills, and are assisted by the conduit in the head, for (like Cetaceous Animals) the Lamprey hath a fistula, spout or pipe, at the back part of the head, whereat they spirt out water, so that both these cavities and the head-pipe together, do very neatly supply the defect of gills,

gills, and execute their office of receiving and ejecting water again.

These sluices and the fistula, shoot themselves slope-wise, and not straight forwards, into the cavity of her neck.

The Heart in this Animal is very strangely secured, & lies immured or capsulated in a Cartilage, or grissly substance, which includes the Heart and its Auricle, as the Scull or Pericranium does the Brains in other Animals; it is of a horny and transparent substance, of an obtuse conical figure, cemented and glewed as it were on all sides to the Pleura, or innermost skin of the Thorax; the Cone or obtuse Tip of this Capsula, butts or shoots it self into the basis of the Liver, which to give way thereunto has an oval cavity or hollownes exactly fit to receive it.

In this Cartilaginous Pericardium, or purse of the heart, is likewise the Auricle co-included, lying not upon the basis of the heart as in other Animals, but laterally adjacent thereunto, insomuch that it being far more flaggy then the heart, they seem to represent the right and left ventricle of the heart. Yet is the Heart, not onely more solid, but seated in the right side, and the Auricle in the left.

If the Lamprey be laid upon her back, and you gently lift up with a probe, the Heart and Auricle; you shall see a fine thin Membrane arise, which separates the Heart from the Auricle, as the *falx cerebri* does separate the left side of the brain from the right.

From this Auricle proceeds a little short Channel, which perforates this separating Membrane, and brings the blood from the auricle into the heart, we thrust a probe just under this Channel betwixt the Heart and the
Auricle

Auricle, to see the blood passe from the Auricle into the Heart; for at every pulse of the Auricle you might see the blood passe through this Channel into the heart; for alwayes, as the blood passed through it was blew, and, when empty, pale, and transparent, that I could easily see the Probe thorow it.

Whilest I had the Probe in this position, with another Instrument and it together, I quite stopped the Channel on purpose to hinder the blood from coming into the heart, which thereupon grew very pale, and in a short time ceased its motion; the Auricle in the interim swelled and was very red. I no sooner opened the Channel to let the blood have a free passage as formerly, but the heart began afresh to beat again.

We pricked the heart while it was in its motion with a large pin into the cavity thereof, and at every systole or contraction, we plainly saw a drop of blood squeez'd and ejected out of that hole.

In this Animal, you may easily distinguish between the motion of the heart and auricle, for there intercedes the time of a pulse twixt the motion of the auricle and the heart; and the heart in every diastole is of a fair purple and ruddy colour, and in every systole pale and wan, as is observable in Frogs and other Fishes also; where you may see the heart to shift colours by turns, as it receives or ejects the blood in the performance of the circulation.

Now the reason of this Cartilaginous Capsula of the heart in this Creature, might be its defect of bones and those costal ribs, which serve others to secure the heart from all external violence; for, she wanting these, had not Nature wisely secured and capsulated the heart in this gristle, it had been subject to all external injuries,

ries, which might have hindred the motion, and endangered the life of the Animal.

This horny Capsula, also served instead of a Diaphragm to part the lower Venter from the Thorax.

The Lamprey likewise hath no bones: for the spine or back-bone, it hath a Cartilaginous flexible Tube or Channel, without any *Vertebræ* or Spondyls in it, hollowed or tubulous from one end to the other; in which lay the Spinal Marrow, which was of a serous, thin, and milky substance.

In some Lampreys, I have found the Liver (as Doctor *Brown* writes) of a pure grass-green colour, which remain'd and kept that tincture whilst the Animal lived; but when I had cut it out of the Body, and layd it by, it presently turned into a faint Olive-colour. Besides I have in the beginning of *April* cut up many Lampreys, whose Livers were of no such colour at all, but a dull yellow, like that of Eels and other Fishes.

So that in this Animal, and Snakes also, you may distinctly see the Bloud's Circulation.

OBSERVAT. XXXIII.

Corns of Sand, Sugar, and Salt.

IT is worth an Hour-glass of Time to behold the Crystal Sands that measure it; for they all seem like Fragments of Crystal, or Alum, perfectly Tralucents, of irregular polyhedral figures, not any one globular: every Corn about the bigness of a Nutmeg, or a Walnutt: which from their unequal superficies refracting
and

and reflecting the Suns rays, seem here and there of Rainbow-colours.

Being layd of a row or train, they seemed like a Cawly of Crystal Stones, or pure Alum Lumps: So that now we need not so much wonder with the Vulgar Philosophers, how so clear and glorious a body as glass, should be made of so durty, opaque, and contemptible Materials, as Ashes and Sand; since now we are taught by this Observation that Sand, and Salt which is in the Ashes, the two prime Materials thereof, are of themselves so clear and transparent, before they unite into that diaphanous Composition.

OBSERVAT. XXXIV.

A small Atom of Quick-silver.

AN Atom of Quick-silver (no bigger then the smallest pins-head) seemed like a globular Looking-glass) where (as in a Mirrour) you might see all the circumambient Bodies; the very Stanchions and Panes in the Glass-windows, did most clearly and distinctly appear in it: and whereas, in most other Mettals, you may perceive holes, pores, and cavities; yet in \varnothing none at all are discoverable; the smallest Atom whereof, and such an one, as was to the bare Eye, *tantum non invisibile*, was presented as big as a Rounseval-Pea, and projecting a shade; Nay, two other Atoms of \varnothing , which were casually layd on the same plate, and were undiscernable to the bare eye, were fairly presented by our Microscope.

OBSERVAT. XXXV.

Mercurial Powders.

IN those Chymical preparations of *Mercury*, which they call *Turbith-Mineral*, *Mercurius Vitæ*, *dulcis*, sublimate, precipitate, and *Mercury Cosmetical*, you may most plainly and distinctly see the globular Atoms of current and quick φ ; besprinkled all amongst those Powders, like so many little Stars in the Firmament: which shews that those Chymical Preparations, are not near so purely exalted and prepared, as they are presumed to be; nor the *Mercury* any way transmuted, but meerly by an Atomical Division rendered insensible.

That subtle and pure yellow Powder of *Mercury*, called *Mercurius vitæ*, looked like the Yolk of an Egge boyled hard and crumbled to a gross Powder: in it and in that Meal-like Powder of *Mercurius Cosmeticus*, were globules of φ plainly discernable.

OBSERVAT. XXXVI.

*Of the seven Terrestrial Planets, as the
Chymists call them.*

Viz. { ☉ Gold, { ♀ Quick-silver,
 { ☾ Silver, { ♀ Tin,
 { ♂ Steele, { ♀ Lead.
 { ♀ Copper, {

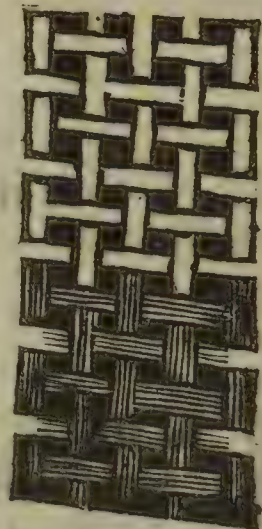
Look at a polish'd piece of any of these Metals and you shall see them all full of fissures, cavities, and asperities, and irregularities; but least of all in Lead, which is the closest and most compact solid Body probably in the world.

OBSER.

OBSERVAT. XXXVII.

Ribbons of all sorts of Colours, Silk, Satten, Silver and mixed.

IN the Silk Ribbons, you might plainly see the Contexture, how the Warp and the West cross one another at right Angles; and how neatly they are platted, just as in this Picture: In Satten Ribbons, one Warp crossed over three or four Wests, most lively and pleasant in Cloth of Silver, the West (being flat wired Silver) that crosses the Warp, it makes a fine Chequered Representation.



OBSERVAT. XXXVIII.

The small Dust, Powder, or Seeds of the lesser Moon-wort.

THAT small pure yellow Meal or Dust, which you may shake off from ripe Moon-wort, appears like a heap of little white round Bugles, or Seed Pearl, and something transparent when the Sun shined, like to some other small Seeds, with a fiber about every one of them like the semi-circular ribbe in a Pompion: So that this Experiment hath decided the old quarrel in Herbalism,

Herbalism, Which is the least of Seeds ; for though Mustard-seed do carry the Vogue amongst the People, yet its exiguity is to be respectively understood, of such Seeds as extend to large productions ; for we see that the Seeds of sweet Marjerom and wild Poppy, are far lesse ; and the Seeds of Tobacco so small that a thousand of them make not above one single Grain in weight : yet must all give place to the super-exiguity of this farinaceous Seed of Wort, which is indeed τῶν σπορμάτων ὀλαχιστότατον.

The exiguity and smalness whereof may very well be one of the *Magnalia* of Nature, somewhat illustrating the great Work of the Creation, and vast Production from Nothing.

OBSERVAT. XXXIX.

The Seeds of Wall-Rue, or white Mayden-hair.

TAKE one of the Leafs of Wall-Rue, (which hath the blackish scurff sticking to the back side of it) and lay it upon the object-plate, and you shall see all the Seeds look just like a sett of black Buttons upon green Taffata ; and every Button or Seed compassed with a circle or ribbe, somewhat resembling a Catterpillar : It hath been the Opinion of old Herbarists, that the Capillary Plants had no Seeds, which errour did rise meerly from a popular inadvertency ; for though these Plants carry not their Seeds in, visible Husks, Pods, Spikes,

Spikes, Fruits, &c. yet are they constantly to be found on the back side of their Leafs.

OBSERVAT. XL.

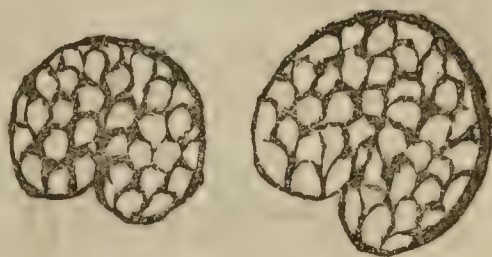
Of the Seeds of Strawberries.

TIs strange to see, what several wayes Nature produceth and secureth the several Seeds of Plants; some are preserved in large Pulps, as the Seeds of all pomiferous Plants. Others, besides the circum-involving Pulpe, are immured in Shells, as all Stone-Fruit, &c. Others, in the lesser Pulp of their Berries, as Mulberries, Rasberries, &c. But in Strawberries, Nature hath put out the Seeds, as if they were sproutings from the Pulp: for those small specks or protuberances on the outside of the Strawberry, are the Seeds thereof, and in the *Microscope* look not unlike the Strawberry; some reddish, yellowish, and green colours, as the Strawberries themselves are.

OBSERVAT. XLI.

Corn Poppy Seeds.

They are none of them globular, nor of a smooth surface, but all like Kidneys in form, and of the seeming bigness of Walnuts, and like an Hony-Comb on the surface, with regular Sides and Angles, making all of them pentagonal and hexagonal areola's; and glistering in the Sun-shine like Tissue, or the Foil on the back-side of a Looking-glass, as is presented in these two Figures. Some other Seeds also looked not unlike them, as Henbane, Flower of Bristow, &c.



OBSERVAT. XLII.

The small Dust or Powder on the Pendants of Lillies.

IN all our common Garden-Lillies (especially the Red and White) out of the middle of the Flower groweth a long style or poyntel, beset round about with small chives, which are tipped with pendants, a single pendent on the head of every Chivall pounced over with a small Dust or Powder, which will cleave to and smut your fingers: this Powder (taken from the yellow
H Lilly)

Lilly) looks very pleasantly in the *Microscope*, of a golden colour, and somewhat diaphanous: where you may see every Atom very distinctly to be of an Oval Figure, exactly like some sort of Seeds: the Powder of the white Lilly pendants, looks of a pure pale yellow, and like so many pieces of polished Amber.

OBSERVAT. XLIII.

The Leafs of several Trees and Plants.

THe backside of a Rose-tree-Leaf, but especially of a sweet Brier Leaf, looks diaper'd most excellently with silver.

The backside of the Leaf of *English Mercury*, called *bonus Henricus*, looks, as if rough-cast with silver, and all the ribs are stuck full of round white transparent Balls, like innumerable Grapes, or Oake Apples, or a Bracelet of Crystal; and we could discover little foot-stalks in many of them, by which they were fastned to the ribs and fibers of the Leaf, which is a very pleasant Spectacle.

A Leaf of Rue looks all full of holes like an Honey-Comb.

A Sage Leaf looks like a white Rugge, or Shagge, full of Knots, tassell'd all with white silver Thrums, and one or two fine round Crystal beads or pendants, as big as Peas, fastned to every Knot.

OBSERVAT. XLIV.

Pink-pendants.

THe chives which grow out of red Pinks, and which are tipped with red Pendants, besmeared over with a small Mealy Powder, look very pleasantly in the Glass; for every Pendent looks like a red Taffata Cushionet, all beset and sprinkled over with round white Beads, or Grumwel-feed.

OBSERVAT. XLV.

Of Nettles.

Look at the backside of a Nettle-Leaf, and you shall see it all full of Needles, or rather long sharp transparent Pikes, and every Needle hath a Crystal pummel, so that it looks like a Sword Cutler's Shop, full of glittering drawn Swords, Tucks, and Daggers; so that here you may autoptically see the Causes, as well as you have formerly felt the Effects, of their Netling. Something like them, appear the Prickles on Borrage-Leafs and Stalks.

OBSERVAT. XLVI.

Gilla Theophrasti.

IT looks pleasantly, like a diaphanous heap of Icicles or striated Niter; but not altogether so regularly figured: but most of them are oblong particles, angular, and pointed, which may perchance exstimulate the Stomach, (by its netling pungency) like a heap of needles, and so promote its vomitory operation.

OBSERVAT. XLVII.

A Nitt.

A Nitt is an Egge glewed by some viscous matter to the sides of the hair it sticks to; it is Oval in shape, white in colour, and full of transparent Liquor or Gelly, and seems to be cased in a brittle Shell by the crackling it makes 'twixt your nails. In the same manner appears a Nitt in a Horse's hair: *Muffet* will needs have it a quick, or rudely-shaped Animal. Thus discursive Argumentation and Rational probabilities mislead men in the Wilderness of Enquiry; but he that travels by the Clew, which his own sense and ocular observation has spun out, is likeliest to trace the securest path, and go furthest into the Maze and Labyrinth of Truth.

OBSERVAT. XLVIII.

A Line drawn upon Paper.

AS these dioptrical Glasses, do heighten and illustrate the Works of Nature, so do they on the other side, disparage and depretiate those of Art: For as they shew the incomparable exactness of the former, so do they discover the flaws and deficiencies of the latter; for a right line either printed or drawn never so neatly upon paper appears all ragged, indented, and discontinued by the rugosities and seeming protuberances of the paper, in which likewise you may see whole clouds, as it were, of raggs, the primitive materials thereof.

I had a Rarity bestowed on me by Master *Taylor* (once a famous Scrivener in these Parts) which is, The Lords Prayer and Creed writ in words at length, and a Breviate also of the ten Commandments, and all couched (but distinctly writ) in the compass of a single penny. In the *Microscope* you might read it all, as if it were writ in Text hand, but all the Letters appeared (as we have observed of the line) crooked and unhandsome; so Inartificial is Art when she is pinched and streitned in her Workmanship.

OBSERVAT. XLIX.

The Sparks of Flint and Steel.

TAKE a good Steel and Flint, and strike fire over a white sheet of Paper, and observe diligently where some eminent Spark falls; for there you shall find a little dark spot or moat, no bigger then a pins point, which through our *Microscope* did appear to be a perfectly round ball polished like Steel or Glass, insomuch that I could see the Image of the Window, and the motion of my hand reflected from it. What this polished Atom is, Master *Hook* has ingeniously conjectured, *viz.* That it is a parcel of the Flint or Steel, or both; which by so violent a percussion is made so glowing hot, that 'tis melted into glass: for first, I observed that it was perfectly globular, and exactly like those glassy Cinders, which are melted at the Iron-forges. Secondly, That it was none of the Atoms of the Steel or Stone, grated off by Collision; for those you might easily see were distinguishable from it; now that so little a stroak, and so small a fire can vitrify, will be better understood by him that knows, how small a heat at a Lamp-Furnace will melt Glass: I have small Capillary Glass-Tubes, which will melt immediately like Wax, if you hold them but near the flame of a common Candle, without any blast at all; by which Artifice I make small Syphons, for the Tryal of many notable Experiments, of which I have treated at large in our *Mercurial* Experiments.

This further I shall adde of Flint, that in it you shall
see

see small Sparks of Diamonds angular, and growing out of the Stone as out of a Mineral bed.

OBSERVAT. L.

Of Hair.

WE slit a black Horse's Hair with a Razor, and perceived it to be hollow, with a white streak like pith in the middle of it; it seemed as big as a Rush, and like a Rush slit length-ways into two. They are none of them Cylindrical, but angular and corner'd, which you may even perceive by your fingers, by twirling a Horse-hair in them: Now though *Borrellus*, and some of our Anatomists, as *Bartholin*, *Riolan*, &c. say the like of the Hairs of a mans head, that they also are hollow within, and angular and corner'd without: yet I could never perceive neither the one nor the other in any of the *Microscopes* I have seen, though I have tried it in four excellent ones, the worst whereof I am confident was better then that of *Borrells*: In all which, I could perceive nothing of an Hair, but that it was like a thin horn something diaphanous (especially in the full Sun) which diaphanity might perchance hinder the appearance both of its cavity and angularity also: for I my self have little glass pipes of so little a Cylinder, and so small a bore, that their hollowness to the bare eye is utterly imperceptible.

And since the bristles and quills in other Animals are sensibly hollow, which are analogous to the hairs in a man; I doubt not, but every one of our hairs is hollow also, which though our Glasses (by reason of their transparency,

parency) cannot present, yet it is palpably evinced by an odde Experiment in *Poland*, where there is a disease (they call the *Plica*) which makes the very hairs of their heads drop bloud at the ends, and if cut any where, to drop bloud there also; which infallibly proves the tubulous cavity of them. Besides, we see the hairs do grain and fork themselves, (when grown too long) which is a sign also of their hollowness.

What, shall we judge them too small to be perforated by Nature? since we see she has perforated Vessels within the Body, as small as hairs, as the *Venæ Lactææ*, and *Lymphæ-ducts*; nay, since we see that Art can blow a glass hollow, and yet as small as a hair; and your Wire-drawers know, that if they take a short piece of Wire, as thick as a quill, and drill it through, that then though they draw it out to the smalness of a hair, yet will it still remain hollow quite through in despite of their Wurdle: which is as great a Miracle in that Engine, as that the like Wire once gilt, shall remain perfectly gilt all over, though it be drawn five hundred yards longer than it was at first; which is an experimental truth, and the dayly practice of our Wire-drawers in *London*. So that the conclusion of this Observation may be this, that every hair of our head is as a little quill or horn, hollow and transparent. Which seems to be further avouched also by the burning of hair; for there you may perceive the same odour and smell, as of burnt horn; and the Chymists, as I remember, draw out of hair a volatile Spirit, exactly like that of Harts-horn: both which experiments do prove an homogeneity and similarity of their substance.

OBSERVAT. LI.

Of Aromatical, Electrical, and Magnetical Effluxions.

SOME with a Magisterial Confidence do rant so high as to tell us, that there are Glasses, which will represent not onely the Aromatical and Electrical Effluxions of Bodies, but even the subtile effluvia of the Load-stone it self, whose Expirations (saith Doctor *Highmore*) some by the help of Glasses have seen in the form of a Mist to flow from the Load-stone. This Experiment indeed would be an incomparable Eviction of the Corporeity of Magnetical Effluvia, and sensibly decide the Controversie 'twixt the Peripatetick and Atomical Philosophers.

BUT I am sure he had better Eyes, or else better Glasses, or both, then ever I saw, that performed so subtile an Experiment: For the best Glasses that ever I saw, would not represent to me, the evaporations of Camphire (which spends it self by continually effluviating its own Component Particles;) nay, I could never see the grosser steams that continually perspire out of our own Bodies, which you see will soil and besmear a polished Glass at any time; and which are the fuliginous Eructations of that internal fire, that constantly burns within us.

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Indeed

Indeed if our Diopticks could attain to that curiosity as to grind us such Glasseſs, as would preſent the Effluvia of the Magnet, we might hazard at laſt the diſcovery of Spiritualities themſelves: however it would be of incomparable uſe to our Modern Corpufcularian Philoſophers, who have baniſhed Qualities out of the liſt of the Predicaments. And truly, as the Learned Doctor *Brown* hath it; The Doctrin of Effluſions, their penetrating Natures, their inviſible paths, and unſuſpected effects, are very conſiderable: for (beſides the Magnetical One of the Earth) ſeveral Effluſions there may be from divers other Bodies, which inviſibly act their parts at any time, and perhaps through any *Medium*: A part of Philoſophy but yet in diſcovery; and will, I fear, prove the laſt Leaf to be turned over in the Book of Nature.

Some Conſiderations, Corollaries, and Deductions, Anatomical, Phyſical, and Optical, drawn from the former Experiments and Obſervations.

Fiſt, Therefore, it is Ocularly manifeſt from the former Obſervations, that, as perfect Animals have an inceſſant motion of their Heart, and Circulation of their Bloud (firſt diſcovered by the illuſtrious Doctor *Harvey*;) ſo in theſe puny *automata*, and exſanguineous pieces of Nature, there is the ſame pulſing Organ, and Circulation of their Nutritive Humour alſo: as is demonſtrated

monstrated by O B S E R V. fourth, sixth, seventeenth,
&c.

Nay, by O B S E R V. sixth, it is plain that a Louse is a Sanguineous Animal, and hath both an Heart and Auricles, the one manifestly preceding the pulse of the other; and hath a purple Liquor or Bloud, which circulates in her (as the Noblest sort of Animals have) which though it be onely conspicuous in its greatest bulk, at the heart, yet certainly it is carried up and down in Circulatory Vessels; which Veins and Arteries are so exceeding little, that both they and their Liquor are insensible: For certainly, if we can at a Lamp-Furnace draw out such small Capillary Pipes of Glass that the reddest Liquor in the World shall not be seen in them (which I have often tried and done;) how much more curiously can Nature weave the Vessels of the Body; nay, and bore them too with such a Drill, as the Art of man cannot excogitate: Besides, we see, even in our own Eyes, that the Sanguineous Vessels that run along the white of the eye (nay and probably into the diaphanous humours also) are not discernable, but when they are preter-naturally distended in an Ophthalmia, and so grow turgent and conspicuous.

To which we may adde, that in most quick Fish, though you cut a piece of their flesh off, yet will no bloud be discernable, though they be sanguineous Animals; but the bloud is so divided by the minuteness of their Capillary Vessels, or percubration through the habit of the Parts, that either it has lost its redness, or our eyes are not able to discover its tincture.

Secondly, It is observable also from the former Experiments, that in these minute Animals their nutritive Liquor never arises to the perfection of bloud, but con-

anually as it were remains Chyle within them, for want of a higher heat to dye it into that Spirituous Liquor: Nay, you shall observe in perfect Sanguineous Animals a Circulation of an albugineous chylie-matter (before the blood have a being) if you take Nature at the rise, and critically observe her in her rudimental and obscure beginnings.

For view but an Egge, (after the second day's Incubation, and you shall see the cicatricula in the Yolk, dilated to the breadth of a groat or six-pence into transparent concentrical circles; in the Centre whereof is a white Spot, with small white threads, (which in futurity proves the Heart with its Veins and arteries) but at present both its motion and circulation is undiscernable to the bare eye, by reason of the feebleness thereof, and also because both the Liquor and its Vessels were con-colour to the white of the Eggs they swum in; but the Heart does circulate this ferous diaphanous Liquor, before (by a higher heat) it be turned into blood.

And one thing here I am tempted to annex, which is a pretty and beneficial Observation of the *Microscope*, and that is, That as soon as ever you can see this red pulsing Particle appear (which Doctor *Harvey* conceived, not to be the Heart, but one of its Auricles) you shall most distinctly see it, to be the whole Heart with both Auricles and both Ventricles, the one manifestly preceding the pulse of the other (which two motions the bare eye judges to be Synchronical) and without any interloping perisystole at all: So admirable is every Organ of this Machine of ours framed, that every part within us is intirely made, when the whole Organ seems too little to have any parts at all.

Thirdly, It is peculiarly remarkable from *Observation*

tion xxxi. That not onely the bloud in perfect Animals, and the chyle in imperfect ones; but also the Animal Spirits have a Circulation, which singular observation hath often provoked and entised our endeavours into a further enquiry after the Nature of these Spirits, as to their Origin or Generation; their activity and motion, with some other eminent properties belonging to them: we shall draw our thoughts together, and so present them to your View: I will not say, that our discourse hereon, shall pass for an un-controllable authentick Truth; it is all my ambition if it attain but to the favourable reception of a rational Hypothesis at last.

A Digression of the Animal Spirits.

First, then, we have not those narrow conceptions of these subtle Spirits to think that they are onely included within the Bodies of Animals, or generated (much less created) there, but we doe believe that they are universally diffused throughout all Bodies in the World, and that Nature at first created this ætherial substance or subtle particles, and diffused them throughout the Universe, to give fermentation and concretion to Minerals; vegetation and maturation to Plants; life, sense, and motion to Animals; And indeed, to be the main (though invisible) Agent in all Natures three Kingdoms Mineral, Vegetal, and Animal.

And lest they should (because of their exceeding volatility and activity) be of little or no use, Nature hath immersed them in grosser matter, and imprisoned them in several Bodies, with which she has intermixed them, the

Microscopical Observations.

the better to curb the boundless activity of so thin and spirituous a substance, and therefore the Spirits (of all compound Bodies especially) ought to be considered under a triple notion :

Viz. Under the state of $\left\{ \begin{array}{l} 1. \text{ Fixation.} \\ 2. \text{ Fusion.} \\ 3. \text{ Volatilization.} \end{array} \right.$

First of Fixation, when they are so complicated with the grosser Particles of Matter, and lockt therein so fast, that they can hardly be separated, and dis-imprisoned as in Minerals, but most especially in Gold.

Secondly, The state of Fusion, I call that, when the Spirits by any kind of help have so wrought themselves towards a Liberty, that they are in the middle way to Volatility, as in half-concocted Minerals, fermenting Vapours or Liquors, and half-ripened Fruits, &c.

Thirdly, The Spirits are in their third state of Volatility, when after a colluctancy with the grosser Particles they have so subjugated and overcome them, that they are just upon wings, and ready to fly away; as in Wine when it is in the height of its fermentation, and in some part of our arterial blood alwayes. Now we observe that those Bodies that relax and open the grosser composition of other Bodies, do presently create a fermentation; for, being like so many Keys, they set the imprisoned Spirits at Liberty, which presently fall on working, and by attenuating the grosser parts, separating the Heterogeneous, volatilizing some, precipitating of others, digesting of others, expelling of others, do at last mould it and work it to such a Body, as the parts of it are fit to make up: In all which interval of time, there is a palpable

pable and sensible heat produced: Thus this Spirit being embowelled in the Earth, and meeting there with convenient matter and adjuvant causes, doth proceed to produce Minerals, creating an actual heat, wheresoever it operates, as in Allum or Copperase Mines, which being broken, exposed, and moistned, will gather an actual heat, and produce much more of those Minerals, then else the Mine would yield, as *Agricola* and *Thurniszer* do affirm, and is proved by common experience.

The like is generally observed in Mines, as *Agricola*, *Erastus*, and *Libanius*, &c. do affirm and avouch out of the dayly experience of Mineral men, who affirm, that in most places they find their Mines so hot, as they can hardly touch them; although it is likely that, where they work for perfect Minerals, the heat which was in fermentation whilst they were yet in breeding, is now much abated, the Mineral being grown to their perfection, as the skilful and excellent Doctor *Jordan* very well infers.

The like heat we observe constantly to be in our Cole-Pits: Nay, we sometimes observe in our Braslumps (as our Colliers call them) which is a kind of Marcasite, a very great heat; for being exposed to the moist Air, or sprinkled with water, they will smoak and grow exceeding hot; and if they be layd up on a heap and watered, they will turn into a glowing red hot fire, as I have seen them my self.

And it was a Casualty once terrible to our Neighbour-Town of *Ealand*; for there, one *Wilson* a Patient of mine, having pil'd up many Cart-loads of these Braslumps in a Barn of his, (for some secret purposes of his own) the Roof letting rain-water fall copiously in amongst them, they all began to smoak, and at last to
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take fire, and burnt like red hot Coals; so that the Town was in an uproar about quenching of them; and one thing further I took special notice of in this unlucky Experiment, that the Water which drained from the quenching of them, left little pieces and Crystals of Copperase sticking all along to the Piles of Grass, that grew in the Croft it run down.

Thus Antimony and Sublimate being mixed together, will grow so hot (the one relaxing the fermenting spirit in the other) that they are not to be touched.

Thus in the Corrosion of Mettals by *Aqua fortis*, what a strong heat is there in the Liquor, and what a steam constantly evaporates during their fermentation. In the Commixtion of Oyl of Vitriol with Oyl of *Tartar per deliquium*, what a violent heat and effervescence do presently arise, besides a sharp and acrimonious vapour that strikes our nostrils. Nay, and we see our Subterraneous Damps do sometimes with intermixture with the moist Air, grow to that over-height of fermentation, that they fire of themselves and strike down all before them.

Thus the Spirit of Niter mixed with Butter of Antimony, grows so hot, that it is ready to rise in a flame.

Thus certainly do all Baths receive their heat from Mineral Vapours, or the Minerals themselves, being in *solutis Principiis*, and so the fermenting Spirit sets a playing in them, as the Learned Doctor *Jordan* did most rationally conjecture.

This universal fermenting Spirit does not onely play these feats in the Mineral; but also operates in the same manner in the Vegetable Kingdome, which we ocularly behold in the Artifice of Malt, where the Grains of Barly being moistned with water, the parts are relaxed,
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the internal Spirits in them are dilated, and put into action; and the superfluity of water being removed (which might choak it) and the Barly being layd up in heaps, the fermentation and heat presently appears, with a kind of vinous steam and effluvioms which passe from it, and therefore it shoots forth into Spires. Thus we see in wet-Hay, how the spirits work not onely to a heat, but (if they be not cooled and prevented by Ventilation) they break out into a flame also; Nay, in all Vegetables there is this constant Heat (though it be below our Sensation) as it is in some Fishes and colder Animals also, and a constant steam and transpiration of particles, as we have experimentally proved in our XXV. *Observation*.

And now let us pursue these Spirits into the Animal Kingdom, and we shall see that they have the like effects and operations there also, as is formerly observed; onely, being there in greater plenty, and more purely refined, and in a constant state of Fusion and Volatility, they work nobler effects.

Now the Spirits that are lodged in all the meats and drinks we receive, being more or less fixed therein; What does the Soul, but (like an excellent Chymist) in this internal Laboratory of Man, by a fermentation of our nourishment in the stomach and guts, a filtration thereof through the *Lactææ*, a digestion in the Heart, a Circulation and Rectification in the Veins and Arteries: what does she, I say, by these several *Physico-Chymical* operations, but strive all this while to unfix, exalt, and volatilize the Spirits contained in our nutriment, that so they may be transmitted to the Brain, and its divarications, and in that reconditory kept and reposit for her use and service.

So that these which we now call Animal Spirits are the purest, subtlest, and most volatile particles and active Atoms of the blood, which by continual pulsation of the Heart are carried with the blood by the carotidal Arteries up into the Brain, and there by that lax and boggy substance are imbibed and separated from the blood, and thence by the Spinal Marrow and Nerves transmitted to all the parts of the Body.

Now as the Chyle is perfected in the stomach and guts, and their appendent Vessels, the lacteal Veins; and as the blood is perfected in the Heart, and its annexed Vessels, the Veins and Arteries: so the Animal Spirits are separated, preserved, and perfected in the Brain, with its continued trunk and branches, *viz.* the Spinal Marrow, Nerves, and Fibers, for the uses hereafter to be declared.

Now the two former Liquors, the Chyle and the Blood (because of their grosser liquidity) need to be conveyed in hollow Pipes and Channels (*viz.* the Veins and Arteries;) but the Spirits which is the quintessence of them both, can easily pass by a swift filtration, through the Brain, Spinal Marrow, and Nerves, Membranes, and Fibers, which are as it were the Cords, Sayls, and Tackling, to move this Engine or Vessel we call the Body.

Nay, though we can give you no sensible eviſtion of it, Why may not all those long filaments of which the substance of the Brain, Spinal Marrow, and Nerves consists, be tubulous and hollow; so that the Animal-Spirits may be channelled through them, as the blood through the Veins and Arteries? I am sure, we see by *Observation xxxi.* and *L.* what infinitely small filaments and vessels there are in Animals, and yet all tubulous
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and perforated; so that the suddain inflation of all those capillary threads or pipes, may serve for Motion of the Body, and the constant though slower filtration of the Spirits through their Coats and Cylindrical Membranes may serve for Sensation. So that it seems, this Cottage of Clay, with all its Furniture within it, was but made in subserviency to the Animal Spirits; for the extraction, separation, and depuration of which, the whole Body, and all the Organs and Utensils therein are but instrumentally contrived, and preparatorily designed. Just as the Chymical Laboratory with all its Furnaces, Crucibles, Stills, Retorts, Cucurbits, Matrasses, Bolt-heads, Pelicans, &c. were made for no other end by the ingenious Chymist, than for the extraction and depuration of his Spirits and Quintessences (which he draws from those Bodies he deals with) in the obtaining of which he hath come to the ultimate design of his indeavours.

Now as in Minerals and Vegetables the colluctancy of these fermenting Spirits with the grosser matter, does both create a constant heat and evaporation of Atoms: So in Animals, the like is more eminently conspicuous, to wit the vital heat, or *calidum innatum*, and those fuliginous effluvia which pass constantly out of us by insensible transpiration; which *Sanctorius* hath proved to exceed the bulk and weight of all our sensible Evacuations whatsoever.

Having thus demonstrated how the Soul obtains these Spirits after her several operations of Digestion, Chylification, Sanguification, Circulation, &c. the like now let us see what use she makes of so pretious a substance.

First, therefore we affirm, that this thin and spiritu-

ous matter, which is called the Animal Spirits, is the immediate Instrument of the Soul, in all her operations both of Sense and Motion. First, for sense, it is plain by what is discovered in a *Vertigo*; for the Brain it self is not of such a fluid substance, as to turn round, and make all objects to do so too; wherefore tis a sign that the immediate corporeal instrument of conveying the images of things, is the Spirits in the Brain. Secondly, That they are the chief Engine of Sight, is plain; not onely because the eye is full of these livid Spirits, but also because dimness of sight comes from deficiency of them, though the parts of the eye otherwayes be entire enough, as in sick and old persons, and in those troubled with an *Amaurosis*, or *Gutta Serena*. I had the last year a Patient, a young Boy of seventeen years old, who fell casually stark blind of his right eye; in which you could outwardly discover no fault at all (the Disease being an *Amaurosis*, or obstruction of the Optick Nerve) for, that Nerve being by successful means dis-obstructed and relaxed, so that the Animal Spirits were able to flow done to the *Retina* again, he shortly after perfectly recovered his sight again, without any relapse at all, to this present day. Thirdly, If you cast a Ligature upon any Nerve, you destroy both the sense and motion of that part whither that Nerve was propagated (as by that pleasant Experiment by tying the recurrent Nerves in a living Dogg, we have tryed) till by relaxing the Ligature the Spirits may have the freedom to channel into the Nerves again: Which truth is also handsomely made out, by that ordinary example of a mans Leg being asleep (as we call it) for by compression of the Nerves, the propagation of the Spirits into the part is hindred; for, as sense and motion is restored,

stored, you may feel something creep into the Leg, tingling and stinging like Pismires (as *Spigelius* compares it) which is the return of the Animal Spirits into that part again. Fourthly, That Spontaneous motion is performed by continuation of the Animal Spirits, from the common Sensorium to the Muscle, (which is the gross Engine of Motion) is sensibly evinced in dead Palsies, where one side is taken away.

To all which add, the former Observation of the Spirits circumundulation when the Snail at any time moved, and of their joint quiescency together.

Having now shown you how these Animal Spirits are generated in our Body, or, to speak more properly, disimprisoned and separated from our nutriment, and so from fixation, brought through Fusion to Volatilization; having also shown you what use Nature makes of them in Sensation and Motion: let us screw our Enquiry a little further, and see if we can discover how the Spirits move in the Brain and Nerves, to perform the same operations. First, therefore, we affirm that a lesser quantity and slower motion of the Spirits is required for Sensation, than there is for Motion; for in this the Muscle swells that moves the part, which is a plain Indication of a greater influx of Spirits directed thither; a greater, I say, for I do not deny but there is required to sensation a moderate quantity and diffusion of the Spirits into all the parts of the Body, else we should alwayes be benumbed and stupid (as when our Leg is asleep) by an interception of the Spirits. Secondly, that their motion is slower in sensation than motion; the former Experiment of the Snail does also manifest: whose Animal Spirits never begin to undulate till she begin to move, whereas she is sensible when they
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are in Quiescency, as you may, by pricking her with a Needle, easily observe. Thirdly, in the return of the Spirits into the stupefied Leg, we plainly perceive by the prickling, what a flow motion the Spirits have. All which *Phænomena* do seem to favour our former Conjecture, that for Motion the Spirits move impetuously down the nervous filaments, (which are hollow;) but for Sensation they onely creep by a filtration down their Coats and Membranes.

Now these Spirits being so subtle and dissipable, the Soul spends them every day in using of them, and they being much spent, she can hardly move the Body any longer: The sense whereof we call Lassitude; For certainly, as Doctor *More* very ingeniously inferrs, if it were an immediate faculty of the Soul to contribute Motion to any matter; I do not understand (that Faculty never failing nor diminishing, no more than the Soul it self can fail or diminish) that we should ever be weary.

Thus are the *Phænomena* of Sense and Motion best salved, whilst we are awake; now what happens when we sleep, is a matter of further enquiry: Some have defined Sleep to be a migration of all the Spirits out of the Brain, into the exteriour parts of the Body; whereas by our former Observations, it may rather seem to the contrary; that is, The retraction of the Spirits into the Brain, or at least a restagnation of them in the nervous parts, does (till Nature being recruited by a new supply and regeneration of them in the Brain) direct them into the Spinal Marrow and Nerves, which being replenished with them again, they run their current as before; so the whole Animal thereby is made capable of feeling the Impulses of any external object whatever (which

(which we call, Waking) and during this Interval and Non-tearm of sensation (for so we may without a Complement call Sleep) why may not the Soul be retracted, and wholly intent upon, and busied about, her Vegetative and Plastical Operations? So that when she has locked up the doors of this Laboratory the Body, she may be busie in augmenting, repairing, and regenerating all the Organs and Utenfils within, and painting and plaistering the Walls without. This I am sure we observe to be the greatest part of her obscure employment in the Womb, where the Embryo for the most part sleeps, whilst the Soul is in full exercise of her Plastick and Organo-Poietical Faculty.

Now these Animal Spirits being continually transmitted from the Brain, through the Spinal Marrow, Nerves, Tendons, & Fibers, into all the parts of the Body (especially whilst we are awaking) may, some of them at least, have a kind of circulation; for those which perspire not, having lost their motion, may either mix with the bloud *in habitu partium*, or relapse into a kind of insipid phlegm, as Chymical Spirits do, that are not purely rectified, and to be returned back by the Lymphiducts again.

Lastly, I have but one paradoxical and extravagant *Quære* to make, and that is this: That since we have proved these Animal Spirits to be the ultimate result of all the concoctions of the Body, the very top and perfection of all Nature's operations, the purest and most ætherial particles of all Bodies in the World whatsoever, (and so consequently of nearest alliance to Spiritualities) and the sole and immediate instrument of all the Soul's operations here, even *in statu conjuncto* (the Body and the Organs thereof, being but secondary and subservient Instruments.

Microscopical Observations.

Instruments to the Spirits:) These things being thus premised, may it not be probable enough that these Spirits in the other World, shall onely be the Soul's Vehicle and Habit, and indeed really that τὸ σῶμα πνευματικόν, mentioned by the Apostle; by a vital re-union with which, it may supereminently out-act all that ever she was able to do in this earthly Prison and heavy Cottage of the Body; since also (which I may super-adde) those volatile Spirits (being freed by a constant and perpetual dissipation from the Body) are diffused through this great ætherial Ocean, as into their proper Element, ready to be united to the Soul at the instant of her Separation.

Fourth Deduction.

FOURTHLY, The Physiologist also may gather something from the former Observations, touching the nature of Colours; that they are indeed nothing but the various modification of Light. For most, if not all, Bodies in their minute particles (through which the Sun's Rays have more freedom to penetrate) seem to lose their Colours, and grow diaphanous, as you may observe in the *Microscope*.

Secondly, Is it not shrewdly probable, that since motion is the cause of sight, (which is nothing else, but the impulse that the Luminous Atoms make upon the *Retina*;) Is it not, I say, shrewdly probable, that Colours are nothing else but a various modification of this motion, since we see that they are both naturally and artificially made by light, to which we can imagine nothing to be added or deducted to super-induce those fine Tinctures

as in the Rain-bow, the Prisme, crystal Pendants, Glass-Globes filled full of water, and in those arenulous Atoms in the former *Experiment* xxxiii. except some change in the motion of the Luminous Atoms, which must necessarily follow from the diversities of Objects and Mediums they either hit upon or pass thorow; and so consequently do either accelerate or retardate the Solary Atoms in their Dinetical and progressive Motion; whence arises both the diversity and variety of all colours whatsoever, as that profoundest Master of Mechanicks (*Des-Cartes*) hath both subtilly excogitated, and ingeniously illustrated by the Prisme.

To which we shall add some further experimental Evidence :

First, If the Hole (through which the Species is transmitted into a dark room) be covered with a leaf of Beaten Gold, it will not onely look of a pure green colour, but all the light trajected through it will put on the same Tincture.

Secondly, If with a Prisme you strike the Rainbow-colours upon a wall, and observing where a red is projected, you there place an Eye, the Spectator shall judge it to be another colour ; because that the Solary Atoms, which shot through the Prisme upon the wall, and there painted that colour, being again and again refracted by the Diaphanous Humours of the Eye, must needs, in all reason, exchange their motion , and so consequently paint the Retina with another colour: both which Experiments shew, that Colour is nothing else but the modification of Light, which by the alteration of its motion is dyed into colours. The like Artificial alteration of the Colours may be made by interposing a Burning-
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Glass 'twixt the Prisme and the Light, and 'twixt the Prisme and the Paper.

But this *Cartesian* Theory of Colours we shall further make out by several Experiments in the Extraction, Commixtion, and Transcoloration of Tinctures. First therefore,

If into the Infusion of Violets you put some few drops of the oyl of Tartar *per Deliquium*, it will presently strike it into a green Tincture: now, if instead of that oyl you put in oyl of Vitriol, it strikes it into a purple Colour: to which if you super-add some drops of Spirit of Harts-Horn, it strikes it green again.

Secondly, If into the Tincture of dried Roses (drawn in Hot-water with oyl of Vitriol after the usual manner) you drop a few drops of Spirit of Harts-Horn, or of Urine, or of oyl of Tartar *per Deliquium*, it will presently strike the red into a green Colour; which by a super-addition of the oyl of Vitriol, you may re-tincture as before.

Thirdly, If into an Infusion of Copperose you shave a little Gall, it presently puts on a Sable inky Colour; into which if you put a few drops of the Spirit or oyl of Vitriol, it strikes out the Colour immediately, and the water becomes white again; to which if you super-add a few drops of oyl of Tartar *per Deliquium*, it re-denigrates it again.

Thus a Glass of the Sweet-Spaw-water also, upon the Infusion of Gall, turns into a Claret-colour: but if you drop but a little of the said oyl or spirit into it, it presently eats out the Colour, and the water returns to its primitive clearness again.

Draw a faint Tincture of Brasil wood, bruised or rasped in luke-warm water, filter it, and clarify it; then if
you

you add a little sharp vinegar to a good quantity of it, it will strike it into the exact colour of good stale English Beer, and it will partly have the smell of it also.

Secondly, If into another quantity of the said reddish Infusion you add a few drops of the oyl of Tartar *per Deliquium*, it will turn it to a pure purplish red, like excellent Claret.

Thirdly, If into this Artificial Claret you drop a few drops of the oyl of Vitriol, it will turn it into a pale Amber colour (like Sack as may be) which with addition of fair water you may empale as you please. By which ingenious commixtion of Spirits and Liquors did *Floram Marchand*, that famous Water-Drinker, exhibit those rare tricks and curiosity's at *London*, of vomiting all kind of Liquors at his mouth.

For, first; Before he mounts the Stage, he alwayes drinks in his private Chamber, fasting, a gill of the Decoction of Brasil; then making his appearance, he presents you with a pail full of luke-warm water, and twelve or thirteen glasses, some washed in vinegar, others with oyl of Tartar, and oyl of Vitriol; then he drinks four and twenty glasses of the water, and carefully taking up the glasse which was washed with oyl of Tartar, he vomits a reddish liquor into it, which presently is brightned up and ting'd into perfect and lovely Claret.

After this first assay, he drinks six or seven glasses more (the better to provoke his vomiting) as also the more to dilute and empale the Brasil Decoction within him, and then he takes a glass rinsed in vinegar, and vomits it full, which instantly, by its acidity is transcoloured into English Beer; and vomiting also at the same time into another glass (which he washes in fair water) he

presents the Spectators with a glass of paler Claret, or *Burgundian* wine; then drinking again as before, he picks out the glass washed with oyl of Vitriol, and vomiting a faint Brasil-water into it, it presently appears to be Sack; and perchance if he wash'd the one half of the glass with spirit of Sack, it would have a faint odour and flavour of that Wine also.

He then begins his Carouse again, and drinking fifteen or sixteen glasses, till he has almost extinguished the strength and tincture of his Brasil water, he then vomits into a Vineger-glass again, and that presents white Wine. At the next disgorgement (when his stomach is full of nothing but clear water indeed (which he has fill'd so, by the exceeding quantity of water which at every interval he drinks) he then deludes the Spectators by vomiting Rose water, Angelica water, and Cinamon water into those glasses which have been formerly washed with those Spirits. And thus was that famous Cheat perform'd, and indeed acted with such a port and flowing grace, by that *Italian* Bravado, that he did not onely strike an Admiration into vulgar heads, and common Spectators, but even into the judicious and more knowing part of men, who could not readily find out the ingenuity of his knavery.

The Chymical Elaboratories likewise do teach us this Truth in Fumes and Smoaks, as well as Liquors (which indeed are but rarified and expanded Liquors;) for *Niter* it self, though nothing a kin to redness doth in distillation yield bloud-red Fumes (called by the Chymists Salamanders-bloud) which fall again into a Liquor which hath nothing of red in it.

So Soot (though black) yet when it is pressed and forced up into an exhalation by a strong fire, will fill the

the Receiver with Milk white Fumes ; thus Sall-Armoniack, and black Antimony, being equally mixed and gradually sublimed in an Urinal, will exhibit a Scene of Colours, and will make a transition out of one into another with a delectable variety.

By all which pleasant Observations, it palpably appears that the nature of Colours consists in the free admission, transition, refraction, or reflection of light, from the Objects discoloured ; For first, you see several Colours introduced into Liquors by those Ingredients, that neither had nor could communicate any such tincture. Secondly, 'tis as plain, that the minute Particles and Atoms of those Bodies that were imbibed by the Liquors, and filled up their smallest Cavities or Interstices, accordingly as they were altered in their situation, and motion ; so were the Luminous Beams variously transmitted, refracted, or reflected, and so consequently thence resulted those several Scenes of Colours.

Thus when the Atoms wherewith the Liquor is fully impregnated do relax and open themselves, that the light may fairly penetrate, then is the Liquor limpid and clear ; but if they draw up a little closer one to another, so that the light be refracted, then is the Liquor yellow ; if closer yet to a greater refraction of the Light, then is the Liquor red: but if in this rendezvous they draw up into a very close Body indeed, so that by reason of their contiguity, both in rank and file, no light can be trajected through them ; then opacity and darkness arises: If the Rays cannot break the front of them, then is a milky-Whiteness presented there.

The

The Fifth COROLLARY.

Anatomical Considerations about the Eye.

OUR next Reflections shall be made upon the Eye, to admire as well as contemplate Nature's variety in the constructure and conformation of so excellent an Organ: The two Luminaries of our *Microcosm*, which see all other things, cannot see themselves, nor discover the excellencies of their own Fabrick: Nature, that excellent Mistress of the Opticks, seems to have run through all the Conick Sections, in shaping and figuring its Parts; and Dioptrical Artists have almost ground both their Brain and Tools in pieces, to find out the Arches and Convexities of its prime parts, and are yet at a loss, to find their true Figurations, whereby to advance the Fabrick of their *Telescopes* and *Microscopes*: which practical part of Opticks is but yet in the rise; but if it run on as successfully as it has begun, our Posterity may come by Glasses to out-see the Sun, and Discover Bodies in the remote Universe, that lie in Vortexes, beyond the reach of the great Luminary. At present let us be content with what our *Microscope* demonstrates; and the former Observations, I am sure, will give all ingenious persons great occasion, both to admire Nature's Anomaly in the Fabrick, as well as in the number of Eyes, which she has given to several Animals: We see the *Tunica Cornea* in most Insects is full of perforations, as if it were a *Tunica Uvea* pinked full of Holes, and whereas perfect Animals, have but one Aperture, these Insects have a thousand Pupils, and so see a Hemisphere

Hemisphere at once: and indeed 'tis worth our consideration to think, that since their Eye is perfectly fixed, and can move no wayes; it was requisite to lattice that Window, and supply the defect of its Motion, with the multiplicity of its Apertures, that so they might see at once what we can but do at several times, our Eyes having the liberty and advantage to move every way (like Balls in Sockets) which theirs have not.

Secondly, We observe no diaphanous parts in those lattic'd Eyes, since it is probable, that the Horney Coat of the Eye serves also for a *Pericranium* for their Brain: For, that the Brain of most Insects lies in their Eyes, seems to me more than a probability. First, because in Flies, Butter-flies, Bees, &c. you can find no other place in their Heads, wherein any matter analogous to the Brain, can be lodged. Secondly, in the Eyes of those Insects you shall alwayes find great store of a pulpos substance, like to be Brain in those Creatures. Thirdly, the Eyes in all Insects are very large, and seem disproportionall to so small Bodies, if intended for no other use than Vision. Fourthly, why may not this lattic'd film of their Eye be their *Tunica Retina*, which as it is concave in us, is convex in them; and as it is made of the Brain in us, so it is in them, and therefore lies contiguous to it, and may indeed be over-cast, by a transparent *Cornea*, through which the Net-work of this interior film may thus eminently appear; For certainly such Animals as have distinction of Senses, as Seeing, Feeling, &c. must needs have an Animal-Sensation; an Animal, I say, for I hold also a natural Sensation, which is performed without a Brain, and such an one is discoverable even in Animals, and in our own Selves; for besides the Animal-Sensation (whose original is in the Brain)

Brain) the Stomach, Guts, and the *Parenchymata* of the Body, yea and the Bloud too, has a natural Sensation of what is good, and what is bad for them, as Doctour *Harvey* has excellently proved, *Lib. de Gener.* and so some of the lowest rank of Animals (as the *Zoophyta* and plant-Animals) may perchance be utterly devoid of Animal, and have onely a Natural Sensation; but this belongeth to some Anatomical Observations I have by me, where I may perchance prove that all Vegetables (as well as the Sensitive and humble Plants) have this latter kind of Sensation, as well as Animals.

But let us return to the Eye again, of which curious Organ I am tempted to say much more; but that I have reserved that discourse as more proper for my Telescopical Observations. Onely for the present, to encourage the Lovers of free Philosophy, and to let them see that even the greatest Oculists and Dioptrical Writers, that the World ever saw, *Kepler*, *Descartes*, *Scheimar*, and *Hugenius*, have not yet discovered all Nature's Curiosities, even in that Organ; I will here deliver one or two Optical Experiments: The first hints whereof, I must ingeniously confess, I received from some Fragments and Papers of our famous, and never to be forgotten Country-man, Master *Gascoign* of *Middleton* near *Leeds*, who was unfortunately slain in the Royal Service for His late Majesty; a Person he was of those strong Parts and Hopes, that not onely we, but the whole World of Learning suffered in the loss of him.

Take a fresh Eye, and, in a frosty Evening, place it with the Pupil upwards, where it may be frozen through, then in the Morning you may cut it as you please. If you cut it with a plain Parallel to the Optick Axis (which
Section

Section *Des-Cartes* thought impossible) then shall you see all the Parts, as he has pictured them *pag.* 92. and each part will be very different in colour, and remain in their natural Site, which may be pricked forth in an oyled Paper: By this trick also you shall find, that there is a double Crystalline humour, one circum-included within the other; if you do but thaw the Crystalline you shall see the outward will pill off from the inward: The right Figures of both which Crystallines are monstrous difficult, if not impossible, to find out; hence it follows that every Ray of incidence is seven times refracted in the Eye before it reach the *Retina*, whatsoever *Scheinar* says to the contrary.

The second Experiment, is one of the ingenious *Ex-cogitations* of *M. Gascoign's*, and it is to delineate the prime parts of the Eye; after this manner: Having a Glass and Table fitted to observe the Eye's spots, place an Eye with the Horny Tunicle either upwards or downwards, between the inmost Glass and Table; so near the Glass, as the Eye will almost fill up the compass of the Eye's Image, then the representation of the Eye will be very large (proportionable to the Eye's Image) upon the Table, and thus you may prick out the three Figures of the *Cornea*, and the outward and inward Crystallines. Many other neat wayes with my Dioptrical Glasses can I take the Figures of the prime Parts of the Eye, which shall be discovered in their fit places.

And now having done with the Fabrick, the Observations lead us to the Consideration of the Number and Plurality of Eyes, that Nature hath afforded some Creatures. I must confess though I have been very curious and critical in observing; yet I could never find any

M

Animal

Animal that was monocular, nor any that had a multiplicity of Eyes, except Spiders, which indeed are so fair and palpable that they are clearly to be seen by any man that wants not his own. And though *Argus* has been held as prodigious a fiction as *Polypheme*, and a plurality of Eyes in any Creature, as great a piece of monstrosity, as onely a single one; yet our glasses have refuted this Errour (as *Observat.* viii. and ix. will tell you:) so that the Works of Nature are various, and the several wayes, and manifold Organization of the Body, inscrutable; so that we had need of all the advantages that Art can give us, to discover the more mysterious Works of that divine Architectress; but especially, when she draws her self into so narrow a Shop, and works in the retiring Room of so minute an Animal.

Lastly, Many more hints might be taken from the former Observations, to make good the Atomical Hypothesis; which I am confident will receive from the *Microscope* some further advantage and illustration, not onely as to its first universal matter, Atoms; but also, as to the necessary Attributes, or essential Properties of them, as Motion, Figure, Magnitude, Order, and Disposition of them in several Concretes of the World; especially if our *Microscopes* arise to any higher perfection: and if we can but, by any artificial helps, get but a glimpse of the smallest Truth, it is not to tell what a Fabrick of Philosophy may be raised from it; (for to conclude with that Patriark of Experimental Philosophy, Sir *Fran-* the Learned Lord *Bacon*,) The Eye of the Under-
standing *Bacon* standing, saith he, is like the Eye of the Sense; for as
 Nat. Hi- you may see great Objects through small Cranies or
 story Levels; so you may see great Axioms of Nature, through
 Exp. 91. small and contemptible Instances and Experiments.

These

Microscopical Observations.

83

These are the few Experiments that my Time and Glass hath as yet afforded me an opportunity to make, which I hasten out into the World to stay the longing thereof ; But you may expect shortly from Doctor *Wren*, and Master *Hooke*, two Ingenious Members of the Royal Society at *Gresham*, the Cuts and Pictures drawn at large, and to the very life of these and other Microscopical Representations.

The End of the *Microscopical Observations.*

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Printed in the Year 1785



Liber Secundus.

Mercuriall Experiments.

Begun *Anno Domini* 1653.

By

HENRY POWER, M^r. D^r.

Itaque sperandum omnino est, esse adhuc in Naturæ sinu; multa excellentis usus Recondita; quæ nullam cum jam Inventis Cognationem habent, aut parallelismum, sed omnino sita sunt extra vias phantasiæ, quæ tamen adhuc Inventæ non sunt, quæ proculdubio, per multos seculorum circuitus & ambages, & ipsa quandoque prodibunt. Fr. Verulam, lib. 1. Novi Organi, sect. 109.

The



The Second Book.

These Physico-Mechanical Experiments are of four sorts, } Hydrargyral,
Hydraulical,
Pneumatical, and
Mixt.

Such things as are requisite for the triall of these Experiments, are

1. *A Quart at least of (☿) Quicksilver.*
2. *Several Glass-Trunks, or Cylindrical Glass-Tubes, some open at both ends, and some exactly closed; or (as they phrase it) Hermetically sealed at the one end. All of several Lengths and Bores.*
3. *A Glass-Tunnel or two, with wooden dishes and spoons, for filling of the Glass-Tubes with Mercury.*
4. *You must have no Metalline Utensils about you, for fear they be spoiled with the Mercury.*
5. *Spread a Blanket or Carpet on the ground when you try these Experiments, that so none of the Mercury may be lost, but may be taken up again with wooden spoons.*
6. *You may have by you also Glass-Syphons, Weather-Glasses of several right and crooked shapes, &c. the more to advantage the Experiments.*



MERCURIAL EXPERIMENTS.

CHAP. I.

Experiment 1.



Take a Glass-Tube of above 29 inches in length, as A B, closed at the end B, and open at A: fill it full of Quicksilver, and so close the end A, exactly with the thumb (as with a stoppel;) then reverse it, and putting it and your finger together into the wooden vessel D, fill'd

about two inches deep with Quicksilver, erect it perpendicularly therein; then drawing away your finger from the orifice, you shall see a great part of the

N

Quick-

Quicksilver in the Tube to make a quick and smart descent into the external Quicksilver in the vessel; and after it hath, by several vibrations up and down, found out a certain point or degree, there to stand still and immoveable: so that all the upper part of the Tube (which the *Mercury* has deserted) viz. from E to B, will seem to be a vacuity.

The first Inventor of this noble Experiment, was *Torricellius* the eminent Mathematician, and deserved Successour to the famous *Gallilæo*, to whom all the Common-wealth of Learning are exceedingly oblig'd, because thereby he has excited the greatest modern Wits to higher and nobler Experiments.

In this *Torricellian* Experiment (for so we shall alwayes hereafter call it) let me give you notice of these rare Observables:

1. If the Tube be not longer then 29. inches, the Quicksilver will not at all descend: this we have tryed in several Tubes of 18, 21, and $26\frac{1}{2}$ inches long.

2. In Tubes of a greater length then 29. inches, the Quicksilver will descend.

3. The Quicksilver will not descend lower then 29. inches, or thereabouts; that is, the Cylinder of *Mercury* in the Tube will alwayes be 29. inches in height above the superficies of the restagnant *Mercury* in the vessel.

4. The Quicksilver descends neither more nor less in Tubes of a greater or lesser Bore, provided they exceed the length of 29. inches.

5. How long soever the Tube be, the Quicksilver will fall down to its wonted pitch and stint of 29. inches or thereabouts; as we have tryed in Tubes of 32, $35\frac{1}{2}$, 37, 45, and 50 inches in Longitude, and all of different Diameters and Bores.

6. If

6. If you add any more Quicksilver to that in the vessel, then, that in the Tube rises proportionally the higher: and contrariwise, if you take any Quicksilver out of the vessel, that in the Tube descends lower; and so consequently, the internal Quicksilver in the Tube keeps alwayes the same height of that in the vessel.

7. That you may with great facility move the Tube to and fro in the vessel'd Quicksilver, but not draw it up towards the superficies of the external Quicksilver in the vessel without some reluctancy.

8. That if you tilt or incline the Glass-Tube, you shall see the Quicksilver gradually to ascend till it almost totally fill the Tube, at which Angle of Inclination the atletus or perpendicular will be equal to 29. inches, let the Tube be of what length soever.

9. That upon removal of your finger from the orifice, you shall see the Quicksilver to make a very Quick and Smart descent six inches at least below the standard of its Altitude in the Glass of 45. inches long, and in others more or less; and after a few vibrations up and down, to settle at its wonted pitch and altitude of 29. inches, or thereabouts.

10. That if any thing, considerably hot or cold, be applied to the Superiour part of the Tube, the Quicksilver therein will more or less ascend or descend, as the water in a Weather-glass, though with farr feeblér and more insensible effects: So that any time of the year it will not much desert nor surmount the determinate height and pitch aforesaid of 29. inches.

11. That this seeming vacuity in the Tube would be judged by any one that came in at an adventure, to be nothing but such like illuminated ayr as this we breathe in.

12. If you dip your thumb into the vessel'd *Mercury*, and close the orifice of the Tube therein, and so gently reverse it, you shal see the Quicksilver in the Tube to move more swiftly (though not without resistance, and ebullitions) through that seeming vacuity; and the *Mercury* will pass with such shoggs towards the depressed extreme of the Tube, as will make you apprehend that the Tube will be either beaten out of your hand or broken: none of which *Phænomena* will appear, if you let in the outward ayr into the cavity unpossessed by the *Mercury*. In which Interim of Motion, your thumb will be drawn and suck'd into the orifice of the Tube, not without some considerable pain.

13. If before the removal of your thumb you reimmerge it again into the vessel'd Quicksilver as before, & then draw the Tube perpendicularly quite out of the vessel'd Quicksilver, the Quicksilver in the Tube will rise to the top of the Glas with such a violence as will indanger the knocking out of the head of the Glas, and then the ayr will pass by a speedy ebullition through the Quicksilver, and it will totally descend into the vessel. I once brake a Glas-tube of near forty inches long, by plucking it suddenly out of the vessel'd *Mercury*.

14. That you cannot so cautiously perform this Experiment in any Glas Tube whatsoever, but some little Air will be seen in the top of the Tube, when reversed, and before the removal of your Thumb, like the little Cap of Air in the obtuse end of an Egge; so that if you incline the Tube to what Angle soever (as in the eighth Observable aforesaid) the re-ascending Quicksilver will never totally and exactly fill the Tube, but a little Cap of Air will still stand in the top thereof.

15. That, use all the Artifice and Industry you can,
you

you cannot so cautiously fill the Tube, but that the Cylinder of Quicksilver will seem cragged and itched, and never purely smooth and polished, (though your Glass be never so smooth and dry, and your Quicksilver never so well purged) which interstices are filled up with Particles of Air that lurk ^{twixt} the Contiguities of the Glass and Quicksilver: and which after the descent of the Quicksilver do bubble up, and shoot themselves little by little into that seeming vacuity (as you may ocularly behold them) and doubtless are the occasion and hindrance why upon inclination of the Tube (as in 8. *Observ.*) the Quicksilver cannot totally replenish and fill the Tube again.

16. We filled a Tube of 27. inches with Quicksilver, and after inversion of it into a Vessel of Quicksilver, as in the *Torricellian*-Experiment we perceived, just upon retraction of the finger, the little Particles of Air which remained lurking between the sides of the Tube and the Quicksilver, on the suddain to become more visible, by a violent and rapid dilatation, flying out like so many little Springs wound up, and then all at once set at Liberty.

17. If you immerse the Tube into Vessels of Quicksilver of several Capacities and larger Surfaces, the descent of it will not alter.

18. Observe that the height of the Mercurial Cylinder, which here with us is found to be 29. inches at the least (if you order the Tube handsomely in filling of it) may seem greatly different from the *French* Observations, and those of *Forrain* Experimenters, as *Parricellius* himself, Doctor *Pascal*, *Roberval*, Doctor *Pettit*, and *Pecquet*, who all assign its Altitude to be but about 27. inches. To this I shall onely at present answer, that this difference

difference of the Mercurial Cylinder, may partly arise from the variations of the Climates, the Air being more thin and hot then ours, partly from the difference and altitude of the Atmosphere here and there, (as shall hereafter be made more intelligible) and partly from the diversity of our measures and theirs, or from the club and combination of all these causes joyned together. To which I may well super-add, the negligence or inconsideration of those that try this Experiment; for you may alter the height of the Mercurial Cylinder, as you do rudely or cautiously tunnel in the Quicksilver into the Tube; for I have sometime with exact caution, made it to rise to 30. inches in altitude from the Surface of the restagnant Quicksilver in the Vessel. I set down 29. inches as its determinate height, to which it will for the most mount, though you use but a careless kind of carefulness in the management of the Experiment.

CHAP. II.

That in the superiour part of the Tube there is no absolute Vacuity.

BEfore we proceed to any further Experiments, we will first canvass the Cause of this Primitive one of *Torricellius*, which has given occasion of trying all the rest; and then we will deliver our *Hypothesis*, which I hope will salve all the strange appearances, not onely in this, but in those stranger that follow.

Valerianus Magnus, and some others are so fond to believe

believe this deserted Cylinder to be an absolute Vacuity, which is not only non-philosophical, but very ridiculous.

1. For, the Space deserted hath both Longitude, Latitude, and Profundity, therefore a Body; for the very nature of a Body consists onely in extension, which is the essential and unseparable property of all Bodies whatsoever.

2. Again we have the sensible eviſtion of our own eyes to confute this Suppoſitional Vacuity; for we ſee the whole Space to be Luminous (as by *Obſer.*) Now Light muſt either be a Subſtance, or elſe how ſhould it ſubſiſt (if a bare Quality) in a Vacuity where there is nothing to ſupport it?

3. Again, the Magnetical Effluxions of the Earth are diffuſed through that ſeeming Vacuity, as *per Experiment.*

4. There is ſome Air alſo interſperſed in that ſeeming Vacuity, which cannot be expelled upon any inclination of the Tube whatſoever, as by *Obſer.* is manifeſt.

5. The moſt full Evidence againſt this pretended Vacuity is from the returgenſcency of the empty Bladder ſuſpended in this Vacuity; for, how ſhould it be ſo full blown from nothing? as is by *Exp.* moſt incomparably evinced.

C H A P. III.

*That it is not the Effluviūms of Mercury
that fill up that seeming Vacuity.*

BEfore we come positively to declare, what it is that supplies this seeming Vacuity, let us draw some negative Conclusions, and see if we can prove that it is not supplied with any Spirits Mercurial, or Exhalations: and this we shall most fully do by an ingenious Experiment borrowed from the Mechanical Wit of Doctor *Pascal*, which shall passe for the second in the Bed-roll of our Experiments.

Doctor Pascal's Experiment 2.

THat the deserted part of the Tube, is not filled up with any Hydrargyral emanations, may be thus evinced; because he hath found the same Experiment to succeed in water onely, without any Quicksilver at all: for he took a Tube or Lead-Pipe of 46. foot in length, made close at the one end in casting of it; and having filled it full of water, and reversed it into a paile of water, underneath about a foot deep, he found the water to fall within 32. foot of that in the Vessel; so that the deserted part of the Pipe was 13. foot; so tall a Cylinder of that Liquor, being it seems but æqui-ponderous to a Mercurial Cylinder of 28. inches. *Kircher* and *Birthingius*, it seems, also have tried the like in a Lead-Pipe
of

of a 100. foot long, and an inch diameter; into which at the top was let in a short neck'd weather-glass, or bolt-head, and fastned so to, that no Air could pierce the coement, that luted the Glass and Lead-Pipe together, which Lead-Pipe at the bottome was also fitted with a Turn-cock, which when it was once filled with water would keep it in till they had reversed it into a Hogs-head of water underneath; and then, by a turn of the Cock letting out the water, it deserted the Bolt head, and superiour part of the Tube, wherein appeared this seeming Vacuity.

Experiment 3.

BUT for a further Confirmation of this Truth, let me subjoyn another Experiment, (which shall here pass for our third) of the same Author's.

Take a Glass-Syringe or Squirt; of what length you please, exactly fitted with a Squirt-staff; stop the mouth of your Syringe close with your finger, and so drown it over head and ears with hand, and all, in a large Vessel of water; then draw back the Squirt-staff, and the Syringe will appear a Vacuity (which will pain your finger by an Introsuction of it in at the Orifice;) but if then you erect the Syringe perpendicular, and draw it all out of the water (excepting that end closed by your finger) and then open the Orifice, you shall see the water suddainly arise and fill the deserted Cavity of the Syringe.

Both which Experiments do sufficiently prove that this seeming Vacuity may be exhibited without the help of any Quicksilver at all, and therefore this imagi-

nary Space in the *Torricellian*-Experiment aforesaid, cannot rationally be supposed to be repleated with any Mercurial Effluvia.

C H A P. I V.

Experiment 4.

That it is not Light onely, which supplies this seeming Vacuity.

TAke the Barrel of a long Gun, about 4. foot long, and Bunging up the Touch-Hole, fill it easily with Mercury, and reversing of it into the Vessel'd Quicksilver, as before, you may measure it, to observe the determinate height aforesaid, which you may easily perceive;

First, By the flushing out of the Quicksilver, upon removal of your finger into the Vessel where the restagnant Quicksilver receives it:

Secondly, By the re-ascent of the Quicksilver upon tilting or plucking the Gun quite out of the restagnant Mercury, as also by the forceable introsuction of your finger, if you close the muzzle of the Barrel within the Vessel'd Mercury, and so draw it out and reverse it, as also by the plucks and shogs it will give in that action:

Thirdly, and most perceptibly, By the repletion of it with water, if you draw the Tube gently out of the Quicksilver in the Vessel into a super-incumbent region of water (which you first poured into the same Vessel.)

fel:) for then if you stop the Orifice with your finger, whilst it stands immers'd in the region of water, and so draw it out and reverse it, you shall perceive it full of water.

The like, no doubt, will succeed in Tubes of other Mettals. Again, if Light onely (onely I say, because we do not deny light to be there) fill up that empty Cylinder, it would be certainly far more Luminous (as containing nothing but the pure Solary Atoms) than the external medium and region of the Air about it, which is confusedly intermixed both with airy magnetical and coelestial particles, besides the halituous effluvia of all Bodies whatsoever. But this contrary to *Observat.*

CHAP. V.

That the evacuated Cylinder in the Tube, is not filled with Atmosphærical Air only.

BY Atmosphærical Air, I understand such as we constantly breathe and live in, and is a mixt Body of Luminous and Magnetical Effluvia, powdered with the influential Atoms of Heaven from above, and the halituous Effluxions and Aporrhœa's of this terraqueous Globe below: And that no such Air fills the Superiour Cavity of the Tube, take this Experiment to evince you.

Experiment 5.

HAVING filled, closed, and reversed the Tube A B as before into the vessel'd Quicksilver D, fill up the said Vessel with water about 2. inches deep, then lifting the Tube gently, but perpendicularly out of the vessel'd Quicksilver into the region of water, you shall see the Quicksilver and Water rise to the top of the Glass, and after a short (but confused) intermixture the one with the other, the Quicksilver will totally descend into the Vessel, and the water arise and fill the whole Tube excepting a little cap of Air in the top of the Tube, formerly hinted at in *Obser.* 14.

Now if that Air in the Tube was Homogeneous to this in the Atmosphære, the water would never rise to thrust it out of its proper place, or, if it did, it could not squeeze through the Body of the Tube; but we plainly see the rising water does fill up the place (as likewise the Quicksilver does in the first Experiment, where you tilt and incline it) till it come to that particle of Air, which indeed is of the same nature with ours (and which we told you formerly lurked 'twixt the Concave Surface of the Tube and the Cylinder of Quicksilver) and that neither the rising water nor ascending Quicksilver, can or does exterminate.

This Truth also is manifestly evinced from the twelfth Observable annexed to the first Hydrargyral Experiment, which palpably shows that it is not common Air which supplies that seeming Vacuity.

CHAP. VI.

HAVING drawn the former negative Conclusions, and demonstrated, That it is not Light onely, not *Mercurial* Spirits, not *Atmosphærical* Ayr, which is diffused through that seeming Vacuity, it will be expected we should deliver something positively, and demonstrate what it is.

Pecquet (who I think follows *Robervallius* therein) ingeniously conceives, that the whole mass of Ayr hath a Spontaneous Eleter, or natural aptitude in it self to dilate and expand it self upon the removal of all circumambient obstacles (which he calls the Elastical motion of that Element) so that the particle of Ayr may be understood to be as many little Springs, which if at liberty, and not bound and squeesed up, will powerfully, strongly, and spontaneously dilate and stretch out themselves, not onely to fill up a large room, but to remove great bodies: So that he compares this vast Element of Air, circumfused about this terraqueous Globe, to a great heap of Wooll-fleeces or Sponges, piled one upon another, the superiour particles of the Ayr pressing the inferiour, and hindring their continual tendency to a self-dilatation; so that all the particles of this *Atmosphære* (especially the inferiour sort) strive at all times to expand and dilate themselves: and when the circumresistency of other contiguous Bodies to them is removed, then they flye out into their desired expansion (or at least will dilate so far as neighbouring Obstacles will permit:) Just like the Spring of a Watch (which if the String be broke, presently flies out into its fullest expansion

panfion :) which Elaftick motion in the Ayr then ceafes, when it comes to an æquilibration with thofe circum-jacent Bodies that refifted it.

That this is not onely an Ingenious Hypothefis, but that there is much of reality and truth in it, I think our following Experiment will to fafety of fatisfaction demonstrate.

Onely we differ from *Pecquet* in the ftrict notion he hath of Rarefaction and Condensation, which he fuppoſeth to be performed without either intromiffion or exclusion of any other extraneous Body whatſoever. Now how Ayr or any other Body ſhould diminifh or augment its Quantity (which is the moſt cloſe and eſſential Attribute to Bodies) without change of its own Subſtance, or at leaſt without a reception or exclusion of ſome other extrinſecal Body, either into, or out of the Porofities thereof, ſounds not onely harſh to our ears, but is beſides an unintelligible difficulty.

Now though we cannot by Senſible and Mechanical Demonſtration ſhew how any new Subſtance or Subtler matter (than Ayr is) which enters into the Tube to replenifh that ſeeming vacuity, and to fill up the aerial interſtices (which muſt needs be conſiderable in ſo great a ſelf-dilation) yet we muſt (conſidering the nature of rarefaction aforeſaid) be forced to believe it: and perhaps ſome happy Experimenter hereafter may come to give us a better then this Speculative and Metaphyſical Evidence of it.

That the hollow Cylinder in the Tube is not onely fill'd up with the dilated particles of Ayr, but alſo with a thin Ætherial Subſtance intermingled with them:

1. Let us ſuppoſe therefore (at random if you please)
that

that there is a thin subtle ætherial substance diffused throughout the Universe ; nay, which indeed, by farr the greatest thereof : in which all these Luminous and Opaque Bodies (I mean the Starrs and Planets) with their Luminous and Vaporous Sphæres (continually effluviating from them) do swim at free and full Liberty.

2. Let us consider that this æther is of that Subtil and Penetrative Nature, that like the Magnetical Effluvia, it shoots it self through all Bodies whatsoever, whose small pores and interstices are supplied and fill'd up with this ætherial Substance, as a Sponge with water.

3. Let us add to the former Considerations, that the Ayr hath not onely a strong Elatery of its own (by which it presses continually upon the Earth, and all Bodies circuminclosed by it) but it also ponderates, and is heavy, in its own Atmosphære.

But because I am resolved you shall take nothing upon the trust and reputation of the best Authour, take this Experiment to prove the Ayr's gravitation (*in propria Loco*) as the vulgar Philosophy calls it.

Experiment 6.

TAKE a Wind-gun (which new Artifice is now common) and weigh it exactly when empty, then by plying the Pump-staff charge it soundly and weigh it again, and you shall find it much heavier then before ; yea, a large Bladder, full blown, will weigh more then its self emptied, and manifest this inequality upon a ticklish pair of Scales.

Now

Mercurial Experiments.

Now though this Experiment seems onely to evince the gravitation of Ayr condens'd, yet it consequentially follows, that Ayr also in the Liberty of its own Sphære, is proportionally ponderous (though it is a difficult point Mechanically to evince it, unless we were actually above the Atmosphære, or in a Vacuity to weigh it there in a thinner medium then here we are able to do;) yet, if I mistake not, I have an Experiment in *Banco* which will give some Mechanical Evidence of this great Mystery, which here, with all its consequences, I shall deliver.

Experiment 7.

THe 6. of May, 1653. I took two Tubes, one of 45. inches, the other 35½ in length, and of different Diameters; and filling them both at the Bottom of *Hallifax-Hill*, the Quicksilver in both came down to its wonted pitch of 29. inches, thence going immediately to the top of the said Hill, and repeating the Experiment again, we found it there to fall more then half an inch lower then it did at the bottom or foot of the said Hill.

Pecquet relates, That Dr. *Pascal* himself tryed this Experiment upon a Mountain of 500 perches high, near *Claramont*, and he found Quicksilver there at the Hill to descend lower by three inches, and somewhat more, then it did at the bottom; so that, according to the Analogy & Proportion of both, and some other considerable Circumstances, we might not only Mechanically find out the Perpendicular height of our great Hill here at *Hallifax*, or any other Mountain whatsoever, but venture notably at the height of the Atmosphære it self. For

For, to manage the Principles we have formerly laid down, First, The reason why the Quicksilver descends at all in the first Experiment, is from its exceeding gravity. Secondly, Why it falls no lower then 29. because a Cylinder of that weight does just æquipoise the Elastick power of the Ayr without, and therefore after a few vibrations up and down (as is Observable in all Statick Experiments) they arrive at a Counterpoise.

But the reason now (as to our particular Mountain's Experiment) why the Counterpoise should alter at the top from that at the bottom of the Hill, and the descent of the Quicksilver be so unequal, is not so much from any alteration in the Elastick power and virtue of that Ayr at the top, from that at the bottom of the Hill; as from the variation of the gravity of the Superincumbent Ayr: For, a longer, and so consequently, more weighty Columne of Ayr, presses upon the vessel'd Quicksilver at the bottom of the Mountain, and so makes the Quicksilver in the Tube, rise higher than at the top of the Mountain; which being so much nearer the top of the Atmosphære, a lesser weight of Superponderant Ayr makes a lesser quantity of Quicksilver arise in the Tube: and so come the *Mercurial* Cylinders to vary in their Altitudes, viz. from the natural Supergravitation of more or less of the Superincumbent Atmosphære. So that it is more than probable, that the higher one rises in the Ayr, to try this Experiment, the Quicksilver in the Tube would fall down lower; and if the Experiment could be try'd at the top of the Atmosphære, no Quicksilver at all would remain in the Tube, but fall down to a level with that in the vessel. I could wish that some of our *Canary*-Merchants would get this Experiment try'd at the top of the Pike of

Teneriffe, which is deservedly famed for the highest Hill in the world.

Object. 1. But I see you are ready to reply, and say, That the inequality of the *Mercurial* Cylinder (in the Mountain-Experiment aforesaid) may every whit as rationally be supposed to proceed from a change in the *Elastic* property of the Ayr, which may be more vigorous at the bottom, and more faint and feeble at the top of the Hill, and so force a greater or lesser quantity of *Quicksilver* up into the Tube.

Object. 2. I know how harsh it sounds, That Ayr should gravitate in its own Sphære, and we, and all other Terrestrial Inhabitants, be insensible of it; and that which augments the improbability, is, That Water we experimentally know (which is a fluid and dissipable Body, as Ayr is) does not gravitate in its own proper place; for if we dive never so deep, it's so far from depressing of them lower, or weighing on them, that it is readier to buoy them up again: And why should not we conclude the like of its next neighbouring Element, the Ayr?

To the first Objection, I answer, That though I should grant that there should be some difference in the *Elatery* of some of the aerial particles from others, yet to be so great in so small a distance as four or five furlongs, 'tis not so easily credible.

I shall

I shall answer your Second Objection with this following (which may pass for the 9.) Experiment.

Fill the Tube, as in the first Experiment, and drown both it and the vessel of restagnant Quicksilver (by letting down all carefully with strings into a Hogshead, or great Cistern of water) and you shall see that the deeper you immerge the Tube, the higher still will the Quicksilver in the Tube arise. Let the vessel of water be of a greater or lesser plane in the surface, it matters not; because onely those parts of water that hang perpendicularly over the vessel'd Quicksilver do gravitate upon it: We drown'd a Tube to 25. inches in depth, above the Superficies of the vessel'd Quicksilver, and it rais'd the Quicksilver in the Tube about $1\frac{2}{4}$ above the stint of 29. inches, at which it formerly stood; just according to the fore-observed proportion 'twixt the weight of the Water and Quicksilver: a Cylinder of the former of 32. foot, being but æquiponderant to a Cylinder of the latter of 29. inches.

Of which noble Experiment, we must confess, the first hint was given us, by those acute and singularly accomplished Gentlemen of *Townley-Hall* in *Lancashire*, who were as Judicious as Honourable Spectators of these our *Hydrargyral* Experiments; and whose Mechanical Prognosticks seldom failed, but were still made good by the future event of the Experiments.

By which it most evincingly appears, that water does gravitate in its own Sphære (as they phrase it) which

now we may retort upon the Second Objection, and say, That if water do gravitate, then why not Ayr in their proper Sphære? both being fluid, diffipable, and co-neighbouring Elements; and so consequently whether in Ayr or Water the Experiment be tryed, this effect will follow, That the deeper you immerge the Tube in either Element, the higher will the *Mercurial* Cylinder rise: And contrariwise, As 32. foot of Superjacent water would raise up a *Mercurial* Cylinder of 29. inches; So the same Cylinder of 29. inches is raised by a Column of the height of the whole Atmosphære it self.

But we may by a far more facile and cheaper Experiment evince the gravitation of Water in its Sphære, which is observable in the common Experiment of a Syphon; through which, the water, by Suction, being first set on motion, it is easily observable, that the flux in the extravasated leg of the Syphon, is at first most strong; and proportionally decreases, as the water in the vessel sinks lower and lower towards the bottom of that leg immerg'd in it: which cannot proceed from any other cause imaginable, but from the Supergravitation of the high parts of the water upon the lower, which being thereby more strongly forced up the shorter leg of the Syphon, the flux thereby is stronger in the longer; and so faints, as the bulk of the Superponderant

Water continually decreases.

C H A P. VII.

The Reasons of all those extravagant Phenomena, which we observed in the first Experiment of Torricellius.

I. **B**Ecause the smaller weight of Quicksilver is not able to master the Elastick pressure of the external Ayr.

2. Because then the Cylinder of Quicksilver Superponderates and overpowers both the Ayr's Elastick virtue and gravity.

3. Because at that stint of 29. inches, the internal Cylinder of Quicksilver comes to an æquilibration with the external Cylinder of Ayr, which presses upon the vessel'd Quicksilver.

4. and 5. Because that in wider and longer Tubes there is at first included a greater quantity of Quicksilver, it does more strongly overpower the Elastick resistance of the Ayr, and so will come (though with more vehemence and swiftnes) to its wonted Altitude of 29. inches.

6. Because by Addition or Diminution of the vessel'd Quicksilver there is a change in the Tube and Vessel, but not in the *Mercurial* Cylinder in the Tube; for that alwayes keeps at an equal Altitude from that in the Vessel.

7. Because the *Mercurial* Cylinder is very heavy, and Quicksilver in Quicksilver moves as easily as a Bucket of water in the whole Well.

8. Be-

8. Because thereby there is onely a change in the Tube, but not in the Altitude of the *Mercurial* Cylinder; for in that Angle of Inclination, the Perpendicular is still 29. inches.

9. Because the Quicksilver, by its long descent, having acquired a greater motion than was requisite to bring it down to its determinate Altitude, cannot suddenly stop there, but by several vibrations up and down, gradually comes back to its wonted Altitude; as we see Pendants, which multiply their undulations before they rest in their desired Perpendicularity.

10. Because the Atoms of Fire and Heat (which is alone) penetrating through the Tube, do expand and dilate the ætherial Ayr in that seeming Vacuity, and so consequently depresse the *Mercurial* Cylinder; or else, contrariwise, upon the approach of cold, some ætherial Atoms pass out again through the Glass, and so the *Mercurial* Cylinder mounts higher.

11. Because it is a Medium somewhat thinner than Ayr alone is; the reason of your finger's exuction may be the Elastick pressure of the external Ayr, without striving either to come in it self, or thrust any other Body into the Tube; as also the Tendency of the ætherial Atoms within, to be a free and proportional commixtion with Aerial particles without.

12. Because when the Continuity of the external and internal Quicksilver is broke, the *Mercurial* Cylinder is by the Elastick pressure of the Ayr (which then prevails) forced up into the top of the Tube; which done, then the Quicksilver, by its gravity overpowering, the Atmosphærical, or unexpanded Ayr, falls down, and gives place to the lighter Body.

13. Because no Contiguity, it seems, in dry Bodies
(how

(how close soever) can exclude the interveniency of Ayr.

Having in our last (9. *Experiment*) proved sufficiently the ponderosity of Water, and its gravitation upon the external Quicksilver in the Vessel, we will now come to shew you likewise its gravitation upon the internal Quicksilver in the Tube.

Experiment 10.

WE took such a like A B (as in the 1. *Eperiment*) near four foot in length, and fill'd it full of Quicksilver, except a Segment (A of about 14. inches, which we filled up with water ;) then reversing the Tube, and holding it so long in that posture, till the Quicksilver and Water had exchanged their places, we then drown'd it in the Vessel'd Quicksilver D, and there withdrawing our finger (as in the 1. *Experiment*) the Quicksilver in the Tube descended an inch, and more, lower than the ordinary stint, (viz. within $2\frac{1}{2}$ inches of that in the Vessel :) and this we try'd in Glafs-Tubes of 40. and 45. inches in Longitude: So that the Tube will be replenished with three Cylinders (viz.) of Quicksilver, Water, and Ayr.

In which Experiment there are three or four remarkable Appearances, which ought not to pass our Observation:

1. That after inversion of the Tube into the vessel'd Quicksilver, before you draw away your finger from the Orifice, you may observe continual Bubbles of Ayr to pass through the Water by an Ebullition, and so presently

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sently to create the little Cap of Ayr, formerly observed (in our 14. *Observ.*) though in the interim the Orifice A, be never so closely stopped.

2. That after the removal of your finger, and collapse of the *Mercury* to, as aforesaid, the volatile bubbles of Ayr still pass through the Region of Water for a long time.

3. That if the Cylinder of Quicksilver, included in the Tube, be not above 29. inches, besides that of the Water, no effect at all will follow.

4. That if the Cylinder of Quicksilver, included into the Tube, be but one inch higher than its ordinary pitch, then, upon making the Experiment, it will fall proportionally lower, according to the weight of the Supergravitating Water.

This Experiment, with those considerable circumstances annexed to it, makes the Water's gravitation more eminently appear: For, since 14. inches of Water is almost æquiponderant to one inch of Quicksilver (as is evident by the Statick Tables of *Getaldi*) and the Quicksilver in the Tube being depressed by the Superincumbent Cylinder of Water of 14. inches, it follows, that it would necessarily depress it one inch lower than the ordinary stint.

But unless the Cylinder of Quicksilver be so great, (or at least that of Quicksilver and Water to be so powerful) as that it be able to overcome the Elastick pressure of the Atmosphære, no effect at all will follow, because there can be no descent of either: and as for those Aerial Atoms which pass by bubbles through the Body of the Water, they are those formerly observ'd for to lurk 'twixt the Contiguity of the Quicksilver and Tube; nay, and perchance, and in the Body of the Quick-

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Quicksilver and Water too, because they cease not after the collapſion and deſcent of the *Mercury*.

Thus having Mechanically evinced the gravitation of thoſe two fluid Elements, both Water and Air, in their proper places and regions; we may come to make good the ſecond Part of our *Hypotheſis*, which is the Air's Elaſtick virtue and property. For the demonſtrating of which, take this following Experiment.

Experiment II.

Fill the Tube (as in the former Experiment) and let the Segment A of 14. inches, which was formerly fill'd with Water, be onely fill'd with Air; then, after you have revers'd it into the veſſel'd Quickſilver D, and withdrawing your finger, you ſhall ſee the Quickſilver in the Veſſel ſo to fall, that it came down 16. inches lower then its wonted and determinate Altitude: We fill'd the ſame Tube, of 45. inches long, within two inches of the top, and then reverſing it, as before, it deſcended two inches below the ordinary ſtint.

We alſo tunnell'd into the Tube a Cylinder of Quickſilver, but of five inches in Altitude (letting the Air ſupply the other Segment of 40. inches;) and reverſing it, as before, it fell down within two inches of the Quickſilver in the Veſſel.

Obſerve, that in theſe mixed Experiments of Air and Quickſilver, or Water and *Mercury*, or all three together, that when you have revers'd the Tube, you muſt hold it cloſe ſtop'd ſo long perpendicular, till the ſeveral Bodies have acquired their ſeveral reſpective and proper places.

Q

To

Mercurial Experiments.

To this Experiment likewise we must annex one considerable *Phænomenon* :

First, That before you withdraw your finger, you shall perceive the internal Quicksilver in the Tube, to press so sensibly upon your finger, as if it would force an entrance out, both before and after it was immerg'd in the Vessel'd Quicksilver : which protrusion cannot possibly be supposed to proceed from any other cause, but the Elatery of the included Ayr (for the pressure was far greater than the natural gravity of the whole Tube of Quicksilver could make) which (upon the removal of your finger) having got some Liberty to manifest it self, it depells the Quicksilver so far below its determinate height : Hence it appears, that Ayr, besides its gravity, has a nobler rarefactive faculty, by which it forces the Quicksilver to so considerable a descent, whereas Water, by its weight onely (as is manifest in the precedent Experiment) and no innate Elatery, did depel the Succumbent Quicksilver in the Tube.

But because the Ayr's Elatery is one of the chief parts of our *Hypothesis*, we will not onely make it good by one, but confirm it by many more succeeding Experiments.

Experiment 12.

Fill any manner of Tube, not above 29. inches in Length, half with Quicksilver, and half with Ayr, and then closing your Orifice with your finger, and reversing it into Vessel'd Quicksilver, as in the former Experiments, you shall (upon removal of your finger) see the Quicksilver fall an inch lower then before, as being de-

depell'd by the dilated Ayr; if then you pour water upon the restagnant Quicksilver in the Vessel, to about one inch deep, and draw the Tube out of the Quicksilver into the region of Water above, you shall see the Quicksilver hastily to arise some inches in the Tube, and then the Water and it confusedly to intermingle one with the other. Lastly, (the Quicksilver being wholly descended into the Vessel) the Water will arise to fill the one half of the Tube. This we tried in Glasses of 18, 21, and 27 inches in Length.

In the first it fell 1. inch, in the second it fell $3\frac{1}{2}$ inches, in the third 5 inches, and more, from the first point it stood at, before you immers'd it in the Vessel'd *Mercury*.

This Experiment drew me on to the trial of another: for I thought if Quicksilver would descend with a quantity of Ayr included with it in Tubes below the required pitch and Standard of 29. inches, then probably some such like effect would follow in Water and Ayr (included in any of the longer sort of Tubes) though much lower then 32. foot, which is found to be the Standard of Water in its Ascent in Pumps and other Instruments (as is besides delivered in *Exper.*)

Experiment 13.

VVE therefore fill'd our Glais-Tubes of 45 inches, half with Water, and the rest with Ayr, and afterwards invers'd it into a pail of water, one or two inches deep; the success was, that withdrawing your finger, as before, the internal Water in the Tube, did shoot about two inches lower then before, and with such

like vibrations (though far shorter than those in Quick-silver.) Lastly, if you immers'd the Tube one foot deep in the pail of water, the water in the Tube would rise somewhat higher than before.

Note, that in these two last Experiments, the descent or fall of the Quicksilver or Water, was most notable about the midst of the Tube, *viz.* when it was equally fill'd with Ayr and Quicksilver, or Ayr and Water.

Which Experiments do not onely make good what is formerly delivered of the Ayr's Elastick pressure, but also it renders Doctor *Pascal's* Experiment, of the descent of Water to 32. foot, very creditable to those that want Instruments to try it.

Experiment 14.

VVE also tried that Experiment of *Robertuallius*, quoted by *Pecquet*, pag. 50. I took one of those little Bladders that are in Fishes, (that in the little Fish, call'd with us, a Graining, is best) and after it had been a few dayes dried, I let out all the Ayr, of it, and tyed the mouth of it again so close, that no new Ayr could re-enter; then I gently wet it on the out side, and dropped it down to the bottom of the Tube, that it might the better stick there, and not be buoyed up with the Quicksilver poured in upon it; then cautiously tunneling in the Quicksilver, and reversing the Tube, as in the first Experiment, we found that after the Quicksilver was come down to its wonted pitch, the Fish-Bladder was full blown, and did swim on the top of the Quicksilver; which, upon the admission of the external Ayr, grew instantly flavid and empty again.

Now

Now, what else is the reason of the Bladder's intumescences upon Collapsion of the Quicksilver to its wonted Standard, but the Spontaneous Dilatation and Elastick Rarefaction of that little remnant of Ayr, skulking in the rugosities thereof; and then (upon removal of the circumpressing Quicksilver) expanding it self in the Bladder, as well as that does in the Tube? The reason of its flaccescency, upon admission of external Ayr, is, because then the Elater of the external Ayr is so strong, that it forces the embladder'd Ayr into its former extension and consistency again.

But hold; Before I pass from this Experiment, I must take *Pecquet* in hand, who, upon confidence of this Experiment, insults highly over those that admit not of his Rarefaction, but will introduce a new ætherial substance to intermingle with the dilated Ayr to fill up this seeming Vacuity.

Object. 1. If any ætherial Substance penetrate the Glass-Tube, it rushes in equally on all sides towards the Bladder, pendent in the Centre; and so, in all probability, would rather press and squeeze the vesicle on all sides closer together, than (by an opposite motion, and re-action upon it self) extend and dilate it.

Object. 2. Again, Since it enters in so freely at the pores of the Bladder, what should improue it there? Since the pores, which gave it admittance, are continually open, and manifest themselves so to be, when any external Ayr is admitted into the Tube, for then it seems the æther flies out indeed, and the Ayr is recondensed again into its natural and ordinary Consistence.

Object.

Object. 3. Again, If the Quicksilver descending do impel the æther through the pores of the Glafs, to help the dilated Ayr, in suppliance of that seeming Vacuity; Why should not Quicksilver totally descend, and fill the whole Tube with æther, and so, consequently, Quick-silver should descend in any Tube (though lower than the ordinary stint of 29. inches) whatsoever contrary to Experiment.

Object. 4. But if there be a Superaerial region of Æther, as much lighter and subtiller than Ayr, as Ayr is then Water, How comes any part of it to be diffused, or dispersed throughout our Elements? Or, if it be, Why should not the ætherial particles fly all away to their proper Sphære (or be rather forced thither by the continual pressure of these heavier Bodies?) as we see no Ayr will abide in Water, but is forc'd up into its proper region and Element above it.

Solut. 1. We grant, that the æther pierces equally in on all sides of the Tube, and so likewise on all sides of the Bladder (into which it would not have entred) had there been no Ayr at all which had freely open'd in its dilation to receive the coming æther into its intimate recesses.

Solut. 2. Why the æther hits not out again (during the interim of the Ayr's expansion) may be, because it has either changed its figure, or it and the aërial particles may be in a new motion, which may not cease till overpowred by the re-admission of new Ayr. But what's the reason in a Bladder half-blown, and held to the fire, or laid in warm ashes, the internal Ayr should rise and
swell

swell up the Bladder, as in this Experiment ? If you say, From the Atoms of Fire, or Heat, which penetrate into the Bladder ; the same Objection I then make to you, (as he there to me) Why could they not hit out, as well as in, through the same pores ? The like may be said of the Ayr in a Weather-Glass, upon application of any thing that is hot to the head of the Tube.

Solut. 3. Now, why the Quicksilver does not totally descend, we have told you, is from the resistance of the *Atmospherical* Ayr, which forces up a Cylinder of Quick-silver of that height of 28. inches ; but as we have since declared, if the Experiment could be made at the top of the *Atmosphere* (which is not very high) then it would totally descend, and the æther there would fill the whole Tube.

Solut. 4. It is every whit as probable, that ætherial Atoms may be interspersedly diffused through all our Elements, as that Ayr may be, or the Magnetical effluvia: the same we have made probable (by its being in Water and Quicksilver) and the latter, no man (that knows any thing of Magnetical Operations) doubts of.

Before we take our leave of these subtil and rare Experiments, I will give you that ingenious, but very difficult Experiment of *Auxotius*, as quoted by *Pecquet*, which shall bring up the rere in this Muster-role of our Experiments, and which will confirm all we have formerly delivered.

Experiment

Experiment 15. Of Auzotius.

TAke a long Tube, with a Head like a Weather-Glass, onely open at both ends, as A B, and with a Circular ledge at B (to tye a Bladder about) as also a little pipe G, which opens into the Head thereof, reverse it, and into the mouth of the Head let down a hollow Cube of wood or Ivory C, as large as the Head will contain; which with its four corners may rest upon the neck of the Glass (as in the Second Figure:) then take a small Cylinder of Glass, of above 28. inches, and set it in the middle of the Cube C, and close the mouth of the Head B, and the pipe G with Bladders, so that no Ayr can get in; then stopping the Orifice of the long Tube A, with your thumb, let another tunnel-in Mercury at the top of the small Glass-tube F, which will first fill the Cube C, and then running over, and falling down the Interstices, that the four Angles of the Cube C makes with the neck of the Glass, shall at last come to fill both Tubes: Lastly, closing the Orifice of the great Tube A into the Vessel'd Quicksilver, and there withdrawing your finger, as in the former Experiments, you shall see all the Quicksilver in the small Tube F B, to fall into the Cubical Vessel C, (which being not able to contain it) it, together with all the Quicksilver, in the head and neck of the great Glass-tube, will come down to its wonted pitch E 29. inches of that in the Vessel.

Which shews, the descending Quicksilver perpetually observes its Sandard-altitude from what height soever. But the great business is, If you open the little pipe G, and let in any Ayr, you shall not onely see it to de-

depel the *Mercurial* Cylinder A E, but to force up the Quicksilver out of the Cube C, into the small Tube B F, to its wonted Altitude of 29. inches, and totally to expel the *Mercurial* Cylinder E A out of the Tube: which ocularly demonstrates, that it is the *Atmospherical* Ayr that (in the first Experiment) raises and keeps up that Cylinder of Quicksilver in the Tube of 29. inches in Altitude, or thereabouts.

CHAP. VIII.

Additional Experiments made at Townley-Hall, in the years 1660. and 1661. by the advice and assistance of that Heroick and Worthy Gentleman, RICHARD TOWNLEY, Esq^r. and those Ingenious Gentlemen Mr. JOHN, and Mr. CHARLES TOWNLEY, and Mr. GEORGE KEMP.

THE last year, 1660. came out that excellent Treatise of *Experiments* of Esq^r. Boyle's, with his Pneumatical Engin, or Ayr-pump, invented, and published by him; wherein he has, by virtue of that rare Contrivance, outdone all that ever possibly could be performed by our late *Mercurial* and *Experimental* Philosophers: And, indeed, to give a true and deserved Character of that worthy Production of his, I must needs say, I never read

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any Tractate in all my life, wherein all things are so curiously and critically handled, the Experiments so judiciously and accurately tried, and so candidly and intelligibly delivered. I no sooner read it, but it rubbed up all my old dormant Notions, and gave me a fresh view of all my former, and almost-forgotten, *Mercurial Experiments*. Nay, it had not that effect onely on me, but likewise it excited and stirr'd up the noble Soul of my ever honoured Friend, Mr. *Townley*, together with me, to attempt these following Experiments.

Experiment 1.

WE took a long Glass-Tube, open at both ends, and put the one end into Quicksilver about one inch deep; then at the upper end we poured in water by a Tunnel: the effect was this, (as was prefurmised) That the water rise up to a Cylinder of 14. inches above the surface of the Quicksilver in the Vessel, but then it would rise no higher, but brake through the restagnant Quicksilver in the Vessel, and swim upon the top thereof, which is consonant to the Series and Chain of our former Experiments: wherein it is proved, that one inch of Quicksilver is æquiponderant to above one foot of Water; and therefore there was reason that one inch of restagnant Quicksilver should support a Cylinder of 14. inches of Water, but no more. But as touching this proportion of Water and Quicksilver, because we have formerly only given it to you upon trust from *Maximius Gletaldi*,
Maximus we will now give you an Experimental eviſtion of it.

Experiment

Experiment 2.

VVE fill'd a Glafs-Vial (being first counterpoised with *Mercury*) and then weighed it; afterwards we weighed as much Water in a Glafs-Vial, of a known weight, as counterpoised the *Quicksilver*, and then measuring the water in the *Mercurial* Vial aforesaid, we found it to contain near 14. times as much Water as it did of *Mercury*.

Experiment 3.

VVE fill'd a Tube with *Quicksilver*, as in the *Toricellian*-Experiment, wherein much leisure and accurateness were used in filling the Tube, to make a polite equal *Mercurial* Cylinder, and after immersion thereof into the Vessel'd *Quicksilver*, we put both the Tube and Vessel into a frame made for that purpose, and let it stand perpendicular therein for certain dayes together (*viz.*) from the 15. *March*, to the 20. *April* after, to observe if it would vary and alter its Standard, which we found it do considerably; for sometimes it was half an inch higher or lower then the Mark and Standard we left it first at. I think, according to the variation of the *Atmosphere* in its temperature: and if you observe strictly, you shall see that the *Quicksilver* in the Tube does never precisely observe the same Standard not a day together, nay sometimes not an hour.

Experiment 4.

A Gain, we tried the *Torricellian-Experiment* afore-said, in a Glas-syphon of $46\frac{1}{2}$ inches in length, and after immersion of both ends into two several vessels of Quicksilver, the internal Quicksilver fell down to its wonted Standard of 29. inches in both shanks of the Syphon: having applied warm clothes to the top of the Syphon, the Quicksilver descended in either leg the breadth of two Barley corns lower than the ordinary stint. We gently lifted one of the legs out of the vessel'd Quicksilver, and then the Quicksilver in that leg rose violently up, so that part of it passed over into the other shank: then having speedily again drown'd the afore-said leg into the Vessel, we observ'd the Quicksilver in both legs to have fallen much (upon the admission of that Ayr) and to stand in both legs at an equal pitch and height, as it did again the Second time, upon admission of a little more Ayr, though the Quicksilver then did not rise high enough to pass over into the other shank as before.

Experiment 5.

WE took the same Syphon again (as before) and then only fill'd one of the legs with Quicksilver, leaving the other full of Ayr; then stopping both Orifices, reversed both shanks into two several Vessels of Quicksilver, as before; then opening both Orifices, the effect was, That the Quicksilver fell in one Tube, and

and new Quicksilver rose out of the other Vessel into the other Tube to an equal Altitude.

Experiment 6.

VVE fill'd a Tube (though with much difficulty) such an one as is here described, with Quicksilver, then invers'd it into Quicksilver, as before: The first effect was, It fell leisurably down out of the head H, and stood at D, 29. inches in perpendicular from the Quicksilver in the Vessel E.

The second effect was; Ayr being let in 'twixt C and B, the Quicksilver rose from D, its former Standard, to A: So that from A to B, and C to E (for so far as C it fell upon admission of Ayr) made up its wonted Standard again.

Experiment 7.

VVE took a Glafs-Cruet, with a small Spout, and fill'd it with Water, and afterwards luted the great mouth A, so that no Ayr could get in; then turn'd the small Spout downwards, but no Water came out of the Cruet into the open Ayr, inverting likewise the small Snout into Oyl, no Water descended, nor Oyl, though a lighter Liquor, ascended; then filling the former Cruet with Milk, though upon inversion of the Cruet none of it would fall out into the Ayr, yet being invers'd into Water, these two Liquors changed places, the Milk descending in a little still stream, the Water ascending in the same manner in two constant little streams,

streams, running Counter one to another; in the neck of the Cruet we tinged the Water with Indico, the better to distinguish their streams.

Experiment 8.

WE fill'd the former Cruet with Quicksilver, and immers'd the Snout into the Water (having first well luted the mouth of the Vial) but no exchange of place followed, unless by much shaking of the Quick-silver, you forced it little by little out; and so either Water or Ayr passed up instead thereof.

CHAP. IX.

Experiment 9.

APril 27. (1661.) we tryed the *Torricellian-Experiment* in the Porch at the new Church in *Pendle*, (which standeth upon a considerable height) the weather being clear, fair, and moderate, about ten of the clock in the morning, the Tube about 42. inches in length, which we fill'd with very much care and diligence, to make a polite *Mercurial* Cylinder, and there we then found the *Mercurial* Standard to be 28 $\frac{1}{4}$ inches.

We tried the same Experiment with the like accurateness, and in the same Tube, at the Beakon upon the very top of *Pendle-Hill*, on the same day betwixt twelve and one a clock, (the Ayr being there much colder then at bottom, or at new Church aforesaid) though the Sky
was

was as clear; and there the *Mercurial* Cylinder was lower then before at New-Church, by a just inch, being fallen precisely to $27\frac{1}{4}$ inches.

About three a clock of the same day, the said trial was made (with all the former circumstances) at *Barlow*, the lowest place (for conveniency) near the said Hill, much lower then the place of the first trial, the Ayr being very much hotter then at the time of the first trial; and there the Cylinder of Quicksilver was equal to that in the first trial (*viz*) $28\frac{1}{4}$ inches. By which it appears, That (if the Ayr at *Barlow* had remain'd of an equal temperature with that of New-Church) the Quicksilver, in all probability, would have fallen lower then the inch we observed.

Experiment 10.

AT the top of the said Hill, we put into the same Tube (which was divided into 102. equal divisions of spaces) as much Quicksilver, as being stop'd and inverted, the Ayr remaining in the top of the Tube, fill'd $50\frac{1}{15}$, or thereabout, of the forementioned divisions, and the Quicksilver, the remaining part of the Tube. The Tube being thus immers'd, and the finger withdrawn, the internal Ayr dilated so as to fill of the above-mentioned parts $84\frac{1}{75}$. and there remain'd in the Tube a Cylinder of Quicksilver containing in length $11\frac{1}{26}$ inches. We tried the same Experiment at the bottom of the said Hill, the Tubes being fill'd, as above, and the Ayr $50\frac{1}{15}$. dilated to $83\frac{1}{8}$. and the Cylinder was in height $11\frac{1}{78}$. inches.

Experiment

Experiment 11.

WE took another Tube, containing in length from the Superficies of the external Quicksilver into which we immers'd it (for so we measure all our Lengths) about 26. inches, containing equal divisions of space, 31. and about an half, represented here by A B, which we fill'd so with Quicksilver, that being revers'd and stop'd at B, there remain'd 9. divisions fill'd with Ayr from A to E: then the Quicksilver being left at liberty to fall down into a dish underneath, it fell near to the mark 18 to 1. So that the Ayr dilated, fill'd the Space A l, containing of these divisions 17|8, and then the Cylinder l B was in perpendicular height 13|86. inches.

We brought this Tube, with the same Mountain-Ayr in it, by the help of a long Tube of wood, having a dish fastned to the open end of it, and both full of Quicksilver, into which we put our Tube, A B, (which Instrument you have here represented) and at the bottom of the Hill the Quicksilver rose up unto the mark m, under the 17. division. So that the Ayr dilated, fill'd of the equal parts 17|35, and the Quicksilver in B was in height 14|31. inches.

Then we put out this Mountain-Ayr, and let into the Tube the same quantity of Valley-Ayr, which fill'd the part A E, containing also 9. of the equal divisions aforesaid; and then the end of the Tube B opened the Ayr dilated to the mark n. So that it contain'd 17|58. parts, and the Quicksilver in perpendicular height, 14|2.

That

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That you may at one glance behold all the varieties of these Dilatations of Ayr, and height of the *Mercurial* Standard, I have supposed the line A B to represent all the Tubes. A E still represents the Ayr left in them, A D the Ayr dilated, B D the Quicksilver.

In the long Tube.

<i>At the top of the Hill.</i>	<i>At the bottom of it at Barlow.</i>	
A E — 50 15	— 50 15	} Equal parts of Spaces, Inches.
A D — 84 75	— 83 8	
B D — 11 26	— 11 78	

In the lesser Tube.

<i>At the top of the Hill.</i>	<i>At Barlow with Ayr. of y^e Mountain</i>	<i>At Barlow with Valley-Ayr.</i>
A E — 9	— 9	— 9
A D — 17 8	— 17 35	— 17 58
B D — 13 86	— 14 31	— 14 02

Now before we pass to any further Experiment, we think it fit to make and denominate several considerable Spaces of the Tube in the *Mercurial* Experiments, which will avoid both confusion and multiplicity of terms for the future.

Let A B be the Tube in which Quicksilver (in case it were totally void of Ayr) would stand in a perpendicular

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dicular

Mercurial Experiments.

dictular Cylinder above the Quicksilver in the Vessel from B to C. So we shall call that line or space,

B C *The Mercurial Standard.*

But if in the Tube there be left as much external Ayr as would fill the Tube from A to E, and that then the Quicksilver would fall from C to D, and the Ayr be dilated to fill the space A D, then we shall call

B D \equiv *The Mercury.*

C D \equiv *The Mercurial Complement.*

A E \equiv *The Ayr.*

E D \equiv *The Ayr's Dilatation.*

A D \equiv *The Ayr Dilated.*

Where note, That the measure of the *Mercurial Standard*, and *Mercurial Complement*, are measured onely by their perpendicular heights, over the Surface of the restagnant Quicksilver in the Vessel: But Ayr, the Ayr's Dilatation, and Ayr Dilated, by the Spaces they fill.

So that here is now four Proportionals, and by any three given, you may strike out the fourth, by Conversion, Transposition, and Division of them. So that by these Analogies you may prognosticate the effects, which follow in all *Mercurial Experiments*, and predemonstrate them, by calculation, before the senses give an Experimental thereof.

Experiment

Experiment 12.

WE tried the *Pascalian*-Experiment in a Tin-Tube of 33. foot long, made of several sheets of Tin, and closely soldered up with Peuter: To the upper end whereof we fastned a long Glass-Tube, open at both ends; then, having soldered up the lower end, we reared the Tube to a Turret at *Townley-Hall*, and fill'd it with water; then closing the top of the Glass-Pipe, and immersing the other end of the Tin-Tube into a cistern of water a foot deep, we opened the lower end, and perceived the water to fall out of the Glass-Tube into the Tin, but how far we could not tell, onely we conjectured to be about the proportion given by Doctor *Pascal*; viz. that a Cylinder of water stood in a Tube about 32. foot high: but presently our Glass tube, at the juncture to the Tin, began to leak, and let in Ayr: so we could make no further process in the Experiment: onely one thing we observed in filling of the Tube, that after the water which we tunnell'd in had gone down a pretty way into the Tube, part of it (by the rebounding Ayr) was violently forced up again, and shot out at the upper end of our Glass-tube two or three foot high into the open Ayr: Which Experiment may be a caution to Pump-makers, & all Artificers that deal in Water-works, that they attempt not to draw water higher then 33 foot (its Standard-Altitude) lest they lose both their credit, cost, and pains in so unsuccessful a design. For I remember in my Lady *Bowles* her new Water-work at *Heath-Hall*, near *Wakefield*, where the Water is raised at least 16. yards high, the simple workman undertook first to

do it by a single Pump; but seeing his endeavours were frustrated, he was forced to cut his Cylinder in two Pumps, and to raise it, first, eight yards into a Lead-cistern, and then by another Pump to raise it out of that other, eight yards, into a cistern above.

C H A P. X.

NOW to salve all these *Mercurial Phænomena*, as also those mixed Experiments of Quicksilver and Water, Quicksilver and Ayr, Ayr and Water, in single and double Tubes and Syphons of all Bores, divers learned and ingenious Heads have excogitated several neat, though different, *Hypotheses*: For, to omit the whimsies of two Grandees, that is, *Valerianus* and *Hobbs*, which so grossly Philosophize: the former affirming the deserted space in the Tube to be an absolute Vacuity; the latter, to be replenished with this very Common Ayr which we breathe in; which creeping up 'twixt the Contiguity of the Glass and Quicksilver, fills up that conceited Vacuity. To omit these exorbitant Conceits, I find two or three more intelligible and rational *Hypotheses*.

The first is of *Roberval* and *Pecquet*, of the Ayr's Elasticity and Gravitation, which we have formerly embrac'd, onely with this addition, That whereas they will have Rarefaction and Condensation to be performed without any increase or loss of quantity (which can never be conceived) we admit of an ætherial Substance or Matter intromitted and excluded, the Bodies so chang'd as we formerly explicated.

The second *Hypothesis* is of the Vacuist's; such, I mean,

mean, as, though they hold this Spring of Ayr, yet in its dilation will admit of no æther or forrain Substance to enter the pores thereof; but the particles, so dilated, to remain so with interspersed Vacuities: and this opinion hath many eminent Advocates and Avouchers, *Cassend*, Doctor *Ward*, Doctor *Charleton*, &c.

The latest Novellist that hath undertaken this Experimental Philosophy, is one *Linus*, aliàs *Hall*, who hath excogitated a new Principle of his own, whereby he not onely salves all the *Phænomena* in the *Torricellian*-Experiments formerly delivered; but also all those stranger Experiments discovered since by *Gerricus* and *Boyl's* Pneumatical Engines. (His Principles he thus layes down.)

1. That there is an inseparability of Bodies, so that there can be no Vacuities *in rerum natura*.

2. That the deserted Space of the Tube (in the *Torricellian*-Experiment) is fill'd with a small film of Quicksilver, which being taken off the upper part of it, is both extenuated and extended through that seeming Vacuity.

3. That by this extended film, or rope (as he calls it) of dilated Quicksilver, the rest of the Quicksilver in the Tube is suspended, and kept up from falling into the Vessel.

4. That this funicle, or rope, is exceedingly rarefied and extended by the weight of the pendent Quicksilver, and will (upon removal of that violent Cause which so holds it) re-contract it self into its former dimensions again, and so draw up what Body soever it hath hold of along with it; as the effluvia of an Electrick upon its retreat, plucks up straws, or any other thing with it that it is able to wield.

5. That

5. That Rarefaction or Condensation is perform'd without any increase or losse of quantity in the Body so chang'd.

6. That this Extension of the film of Quicksilver, is not indefinite, but hath a certain limit, beyond which it will not be stretch'd; and therefore if the Tube be of an exceeding great height, the Quicksilver will rather part with another film, and extend that, and so a third, or fourth, till it come to the Standard of 29. inches, where it rests; having not weight, nor power enough to separate another film from it self.

Upon reliance on, and encouragement from these Principles, he undertakes all difficulties, and engages with three great Experimental-Philosophers, *Torricellius*, *Schotus*, and *Boyle*, and resolves all the *Phænomena* of their Engines.

1. As first, Why the Quicksilver in the Tube, under 29. inches, descends not at all? Because it sticks with its uppermost surface so close to the top of the Tube, that there is not weight enough to break that adhæfion: the reason whereof is, because there is nothing to succeed in the room of the descending Quicksilver, and therefore it firmly sticks there, *Ne daretur vacuum*.

2. In longer Tubes it falls to that Standard, because then the greater weight of the Quicksilver is able to break that linck of Contiguity or Adhæfion; and therefore the uppermost surface of the Quicksilver being sliced off, is dilated into a tenuous Column, or Funicle, which supplies that seeming Vacuity.

3. The reason why the internal Quicksilver in the Tube does ascend, upon plucking the Tube out of the
restagnant

restagnant Quicksilver, is, Because then (some of the Quicksilver in the Tube falling out) the Contiguity is not onely broke, but the Quicksilver in the Tube being made thereby lighter, the rope is able to pluck it up; which it doth by retracting and shrivelling it self up to the smalness of its former dimension; and thus by no violent distention, but spontaneous, you must perceive all the Experiments of the Weather Glas to be performed by a tenuous Funicle of Ayr, and, in the *Pascalian*-Experiment, by a rope of Water; and so of other Liquors, where this seeming Vacuity is created. By this tast of Philosophy you may easily imagine how he salves all the *Mercurial Phenomena*, and those of the Pneumatical Engine.

The Arguments by which he strives to authenticate and make good his *Hypothesis*, are these four Negative ones; by which he strives to impugn the Doctrine of those that hold the Ayr's gravitation and Elasticity.

The first (which is the main and *Herculean*-Argument) is from the introsuction of the finger, so observable in the *Torricellian*-Experiment: which, saith he, proceeds from something (that is at a stress) within the Tube, and from nothing that is at a full and free Liberty without: this suction and attraction of the finger he proves to be not onely eminently sensible in Tubes above the Standard (whether open at both ends, or closed at the one) but also in Tubes under the Standard of 29. inches: for, saith he, take a small Tube, under the Standard, open at both ends, of 20. inches supposed in length, and fill it with Quicksilver, stopping the lower Orifice with your thumb, then closing the upper with your finger, and

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and immersing the lower into restagnant Quicksilver (as in the *Torricellian-Experiment*) you shall (saith he) upon removal of your thumb (though no Quicksilver fall out) feel a palpable suction of your finger, and the Tube will stick so close to the pulp of your finger, that you may quite lift it out of the Vessel, and carry it (with all the Quicksilver pendent in it) up and down the room. Therefore (saith he) the internal Cylinder of Quicksilver in the Tube is not held up by the preponderant Ayr without; for, if so, whence comes so strong a suction, and so firm an adhæsiion of the Tube to your finger? For if the external Ayr thrust the Quicksilver upwards, it can never at the same time draw down the finger too.

His second Argument, That the standing Quicksilver in the Tube, is not held up there by the external Ayr, is fetch'd also from another Experiment in the same Tube: For (saith he) fill the same Tube almost full of Quicksilver (leaving a little space of Ayr within it) and then immersing it as before, you shall see the Quicksilver to make a considerable descent in it, *viz.* as far as that little Ayr could well be extended, also a strong introsuction of your finger as before: From whence he thus argues; If the external Ayr cannot hold up 20. inches of Quicksilver (as we here see;) How can it hold up 29. I pray you (as in the *Torricellian-Experiment*?) This Experiment, as appears by our *Mercurial-Observations*, we made many years ago.

His third Argument is from the Non-gravitation of the *Mercurial* Cylinder: For, saith he, the Quicksilver in that Station (*viz.* after it has fallen to its old Standard) is

is not all ponderous, as you may perceive by your finger to the Orifice of the Tube; from whence, saith he, 'tis plain, that the Quicksilver is there suspended by that tenuous, but tenaceous, rope in the Tube.

His fourth Argument is from the difficulty of Suction of Quicksilver up a Tube, open at both ends, of what length soever; through which, saith he, water is easily drawn up to the mouth: And why not Quicksilver? Since here is nothing else required but the removal of the internal Cylinder of Air, which is easily done (saith he) by Suction, as is manifest by the ascension of water, but cannot be performed in Quicksilver (which should as easily be thrust up (to 29. inches at least) by the Superincumbent *Atmosphere*) as the water which is repugnant to Experience of the fire: he concludes, 'Tis not the external Air that causes that effect, neither by its Elasticity, Gravitation, nor both.

Now for the Positive Arguments to avouch his Principles by, he has none at all; onely what he fetches *à posteriori*, from his commodious Solution of Difficulties, and salving the *Phænomena* better then others have done. For read him through, and you shall see he hangs so like a Tumbler by this rope, that swing him which way you will, you cannot get him off; though, I doubt not, but we shall prove his cord to be a mere rope of sand, and of his own twisting; and Reason will, *Sampson*-like, break it easily in pieces.

CHAP. XI.

A Confutation of this Funicular Hypothesis of Linus; by Henry Power, Mæ. Dr.

Object. 1. IF you fill a Tube of 45. inches in length (as we have shewed you in *Experiment 11.*) except 15. inches (which let the Ayr supply) and invert it, you shall perceive a greater protrusion of your finger by the erupturient Quicksilver, than can possibly be imputed to the Supergravitation of the Quicksilver included in the Tube: for, if the whole Tube be fill'd with Quicksilver, and inverted, it shall not make such a forcible pressure upon your finger (as that Cylinder of Quicksilver and Ayr does) which can be imputed to no other cause, then the Elasticity of the included Ayr; which, striving to dilate it self, detrudes the Quicksilver; and, when liberty is given, it forces it down much lower than its ordinary Standard of 28. inches: which shewes, that there is no such thing as Attraction in the Ayr, but rather a contrary power of Self-extending, and Dilatation. Now, I confess, this is but an Argument *quoad sensum*, and therefore not so much to be insisted upon, because not Mechanically demonstrable.

Object. 2. Again, this is observable in all Bodies, that are capable of Extension, That still, as their Extension is augmented or increased, so must the force or power be that

that extends them. As for example, in Ropes or Leather, the first inch of their forced extension is performed by a lesser power then the second inch would be, and that then the third, &c. Now in the third of *Boyle's Experiments*, pag. 44. it is observed, That the Sucker is as easily drawn down, when it is nearer to the bottom of the Pump, as when it is much farther off; which is contrary to the nature of forced Extension, as is before delivered.

Object. 3. Again, If (according to *Linus*) the Bladder's intumescency, in *Boyle's Engine*, did proceed from the forced extension of the Ayr in the Receiver; then the first evacuation of the Pump would extend the Bladder more then the second, and that than the third, &c. But the contrary is avouched by his fourth Experiment, pag. 47. which proves against the Funicular Doctrine of *Linus*, but neatly makes out the Elasticity of the em-bladder'd Ayr, which gradually increases, as the debilitated Ayr in the Receiver gives room for its expansion.

Object. 4. Again, *Linus* is refuted by the 19. Experiment in *Boyle*, which is an Experiment of a four-foot Tube, fill'd with water, and inclosed in the Receiver; by which he found that the water, included in the Tube, did not at all subside after several exsuctions, till the Elasticity of the included Ayr was no longer able to support that Cylinder of water; but, according to *Linus*, it should have subsided at the first exsuction, as well as the Quicksilver did when the *Torricellian*-Experiment was included in the said Receiver.

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Object. 5. According to *Linus* his Principles, the *Mercurial* Standard should be the same at the top of any eminent Hill, that it is at the bottom, especially if the Temperature of the Ayr be in both places alike; but this is contrary to the Experiments we tried at *Hallifax* and *Pendle-Hill* (as you may see in *Experiment 7. pag. 19.* also *Experiment 11. pag. 45.*) where the coldness of the Ayr was a disadvantage to our Experiments; and yet, for all that, you see how considerably the *Mercurial* Standard did vary. Which Objection *Linus* has ingeniously confess'd to me himself (when once I had the happiness to see him) that he cannot as yet answer.

Object. 6. Take a Glas-Tube above the Standard, but of a small Bore, (that will not admit above a great Pea, or Cherry-stone) let it be closed at one end, and fill this with Quicksilver (which you shall find no easie thing to do; for I am sure we were a whole hour in filling one, and still were forced to thrust the Quicksilver down into it with a small wire) then reverse it very gently into a vessel of restagnant Quicksilver, and after it has come down to its wonted Standard, you may lift the Tube out of the vessel, and carry it up and down with the Quicksilver pendent in it; which will neither fall out, nor rise up to the top, to fill up the reputed Vacuity. Now what sayes *Linus* to this? Why does not his rope shrivel it self up, and pull up this *Mercurial* Cylinder in this Tube, as well as in all others of a larger Bore?

Object. 7. Take a Glas-Syphon A B, and having fill'd both legs with Quicksilver, open the longer into the vessel'd Quicksilver B; the effect is, That the Quicksilver in the longer shank will fall down to C (its wonted

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wonted Standard;) but that in the short shank A D, being still close stopped with your finger, will remain full.

Now (according to *Linus*) the funicle A C exercises the same power of pulling the *Mercurial* Surface A as C: and according to the Principles of Mechanick's, If C B be heavier than A D, it should pull over A D into the vessel B. And his Answer (which you may read, *pag.* 74. is nothing to the purpose; for open the short end of the Syphon into the vessel D, (according to his *Salvo*) no Quicksilver should still rise, because it is still as closely adherent to the vessel'd Quicksilver, as it was before, to my finger; and yet, upon Experiment made, the Quicksilver will rise all out of the vessel D, and go over A, into the vessel B.

Which Experiment, as it confuteth his, so it clearly avouches our Principles, of the Elastical pressure of the external Ayr upon the surface of the Quicksilver in the vessel D, which forces it up to A, and so over into the vessel B.

Object. 8. We took an ordinary Weather-Glass (this 15. Octob. 1661.) A B, of about two foot in Length, and carrying it to the bottom of *Hallifax-Hill*, the water stood in the shank at C, (*viz.*) 13. inches above the surface of the water in the vessel B, thence carrying it thus fitted, immediately to the top of the said Hill, the water fell down to the point D (*viz.*) $1\frac{3}{4}$ inch lower than it was at the bottom of the said Hill: which incomparably proves the natural Elasticity of the Ayr.

For the internal Ayr A C, which was of the same power and extension with the external at the bottom of
of

Mercurial Experiments.

of the Hill, being carried to the top, did there manifest a greater Elasticity then the Mountain-Ayr there did manifest Pressure, and so extended it self further by C D, which it was not able to do at the bottom, because the Valley-Ayr there was of equal force and resistance to it: Which Experiment very neatly proves the Elasticity of the Ayr (which *Linus* would abolish) as the *Toricellian* Experiment; which being carried to the top of the same Hill (differ'd $\frac{1}{2}$ an inch) did eminently prove the gravitation of the Ayr.

Also about the end of *January*, 1661. we went again to the top of *Hallifax-Hill*, with divers Weather-Glasses of several Bores, Heads, and Shapes; and found in them all a proportional descent of the Water, as in the former Experiment at the top of the said Hill respectively to what it was at the bottom, with this Observable, That in the greatest-Headed Weather-Glass (which included most Ayr in it) the descent of the Water was greater, as being most depress'd, by the greatest quantity of the included Ayr.

CHAP. XII.

*Experiments in Capillary Tubes and Syphons.**Experiment I.*

TAKE a small Capillary Glass-pipe, or Tube, open at both ends; and dipping the one extreme perpendicular

dicular into the water, you shall see the water spontaneously arise to a competent height in the Tube, with a quick and smart ascent.

Note first, That the inside of the Pipe ought to be very clean, as well from dust, and little bubbles, as films of water, which will remain in the Pipe, when the water is blown, or suck'd out of it.

Secondly, It must be perfectly dry from any other Liquors which will not mingle with water, as Oyl, &c.

Thirdly, If you moisten the Pipe first with water, before you try the Experiment, the ascent of the water will be more quick and lively.

Fourthly, That not onely Water, but Milk, Wine, Oil, and other Liquors, except Quicksilver, will likewise rise to a certain height in the said Pipes.

Fifthly, After the Water has risen to its Standard-height, if you take it out of the Liquor, it shall not fall out at all; if you invert the Pipe, the included Cylinder of water will fall down also to the other extreme: also the deeper you immerge it in the vessel of water, the higher still will it rise in the Pipe, still keeping its Standard-Altitude above the surface of the water in the vessel: also if you suck it above the Standard, it will still fall back to its wonted Altitude.

Sixthly, That not onely Water, but Milk, Wine, Oyl, and all other Liquors, will spontaneously arise in the said Pipes; but with this difference, That the heavier the Liquors are, the lower their Standard is, and the slower is their Ascent to it: thus you shall see Oyl of Tartar will not rise, by one third, so high as water; nor Oyl of *Vitriol* by $\frac{2}{3}$ so high as it; which may alter more or less, according to the goodness of the said Oyls.

Seventhly, Now if you take out a Pipe (wherein in either

Mercurial Experiments.

ther of the said Oyls has first risen up to its wonted Standard) and immerge the end thereof into a lighter Liquor (as water) you shall see the Oyl fall gradually out into the water, and the Pipe gradually fill with water, and arise to its own Standard; which is higher a great deal than the Standard of either of the said Oyls, as is before delivered: the like will follow in Syphons.

Eighthly, The smaller Bore that your Tube is of, the higher will your Water arise; yet we could never get it to arise to the height of 5. inches (as Mr. Boyle mentions) though we have attempted it in Tubes almost as small as Hairs, or as Art could make them.

Ninthly, If the Tubes be of the Bore of an ordinary Quill, or bigger, no Water at all will arise.

Tenthly, That little or no difference of the water's ascent in the former Tubes is perceptible at the bottom, or top of our Hill.

Experiment 2.

BEnd one of these Tubes into a little Syphon (which you may do by putting it into the flame of a Candle) and then putting the one extreme thereof into a vessel of water, you shall see it presently fall a running on its own accord. Observe,

1. That the perpendicular height of the flexure of the Syphon to the water's Superficies, be shorter, or at least exceed not that Standard-height, unto which the water would rise, were it a streight Pipe onely.

2. That the pendent Shank hang not onely lower then the water's Superficies, but by such a determinate Length; for we have found, that if the pendent, or
extrava-

extravasated Leg be shorter, or equal, or but a little lower then the Superficies of the water in the vessel, no effect at all would follow; but the pendent Leg would hang full of water, without any flux at all. Now what this determinate length is, we conceive the pendent Shank must be longer from the flexure then the Standard of the Liquor would reach; and then it will run as other Syphons do which have a larger Bore: so that you see, the Mechanical reason (which is so universally received by all men) why the pendent Leg in Syphons must be longer than the other, to make the Liquor run out (*viz.*) because the greater weight of water in the pendent Leg, overpoises and sways down that in the shorter, as in a pair of Scales; is not universally true in all Syphons whatsoever.

3. If to the nose of the pendent Leg you apply a wet piece of Glass, the water then will begin to come out of the Pipe, and run down to the lowermost edge of the Glass; where, gathering it self into round bubbles, it would fall to the ground: but then you must observe that the nose of the pendent Shank be lower than the Surface of the water in the vessel.

Experiment 3.

L Et both Shanks of the Syphon be fill'd with water, so that the pendent Leg be longer than the Superficies of the water (and yet not so long neither as to set it on running) then to the nose of the pendent Leg apply a vessel of Milk, and you shall see, that though the water would not break out of the Pipe into the open Ayr (a medium far lighter, and more divisible than Milk;) yet

Mercurial Experiments.

it did run out into the Milk, and one might see it purl up again without mingling with the Milk, at a little darkish hole, like a Spring. Observe:

Experiment 4.

IF you lift the vessel of Milk (with the pendent Leg drown'd in it) higher towards the flexure of the Syphon, so that the Superficies of the Milk be nearer the flexure of the Syphon than the Superficies of the Water, you shall (after a considerable time) see the Milk rise up the pendent Leg, and to drive back the Water; and having fill'd the whole Syphon, to fall a running into the Water-vessel, with this difference to the former Experiment, That whereas the Water in the former came to the top of the Milk, the Milk here sunk down to the bottom of the Water, in a small stream like a curl'd white thread, and there settled in a Region by it self.

Experiment 5.

NOW, contrariwise, if you lift the vessel of Water nearer the flexure of the Syphon than the Superficies of the Milk is, then will the Water rise over the Syphon and beat out the Milk, and fall a running, as in the third *Experiment*. And thus you may at pleasure change your Scene, and make the Syphon fall a running, either with Milk or Water: which is a pleasant spectacle to behold, especially if the Water be ting'd red with Scutchenel.

My

My Worthy and ever Honoured Friend, Mr. *Charles Townley*, upon confidence of these Experiments, thought he had discovered that great, and long sought-for Rarity amongst the Mechanicks (*viz.*) *A Perpetual Motion*: For the demonstrating of which, he devis'd this following Experiment.

Mr. Charles Townley his Experiment;
from which, he would deduce a Perpetual Motion.

Let the Glass D E F be fill'd with two several Liquors, so as they may remain in two distinct Regions, one above another, as A B, without the least mixture; (which may be performed in Milk and Water, placing a broad piece of Cork, or Bread, that will swim so upon the Milk, which must be the lower, as A, being heavier than Water, that it may receive the force of the Water's fall when you pour it upon the Milk:) this done, and the Cork or Bread being taken out, hang the Syphon A C B, first fill'd with Milk, upon the stick D C E, so artificially, that the longer end A may remain in the Region of Milk, and the shorter end B in the Region of Water; with this caution, That the flexure of the Syphon C be removed no higher from the Milk, than it would naturally ascend to, if the Syphon was streight: Now (saith Mr. *Charles*) Since in the former Experiment the Water would rise over the top of the Syphon, and drive back the Milk; and afterwards rise to the top thereof, and there swim aloft: why here in the Syphon A C B, the like should not follow, (*viz.*) the Water at B drive the Milk,

Milk, (which is suppos'd first to fill the Syphon) back to C, then to A, where issuing out of the Pipe (as it did in the former Experiment) it would ascend to its proper Region of Water again, and so continue in a Circular Motion perpetually.

Now however this same Problem of *M. Charles* might seem probable in the Theory, yet it will prove more than most difficult (if not impossible) in the Practice. For,

1. We fill'd the Glas D E F, half full of Milk, and half full of Water, as A B; then hanging the Syphon (first fill'd with Milk) so artificially on the stick D E, so that the longer Shank might reach the Milk A, and the shorter might open into the Superincumbent Region of Water B, we observ'd this effect, That the Milk did for a small time run out of the Orifice B, and seem'd to fall into the inferiour Region of Milk; but at last the Milk (or at least the ferous or more watrish parts thereof) so intermixed with the Water (which we could discern by the whiteness and opacity of the Water) that the flux was quite stifled.

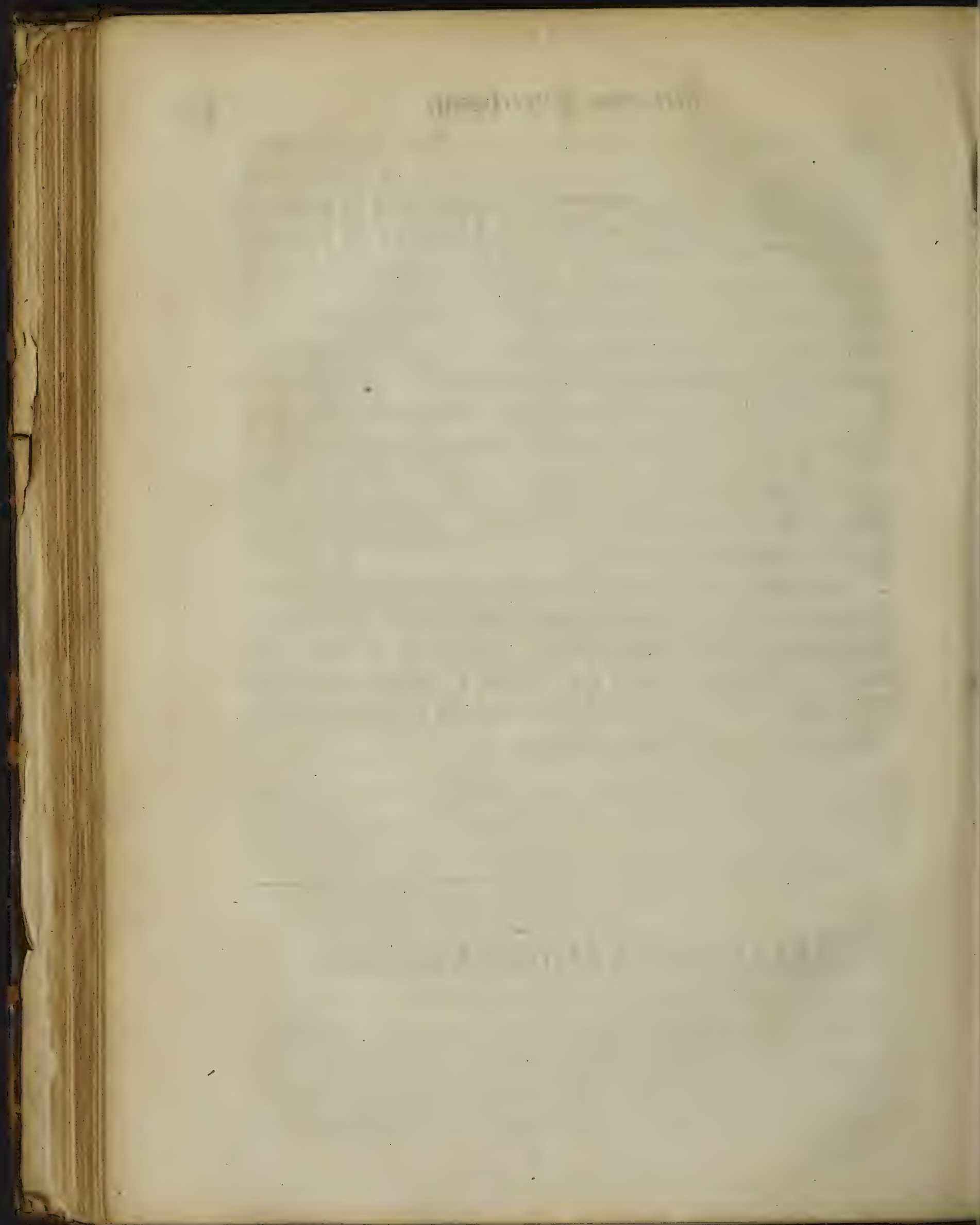
2. Contrary to *Mr. Charles* his Prognosticks, the Water did not rise up the short Shank, and drive back the Milk, but quietly permitted the Milk to drill through it; though I know it was not material which way the flux was performed, provided it would have been perpetual.

The Experiment failing in these two Liquors, we attempted the same again in other two Liquors (which we were sure would not mix;) and to that purpose we fill'd the aforesaid Glas with Oyl of *Tartar per deliquium*, and Spirit of Wine, which we tinged yellow with Saffron, the better to distinguish the Liquors; and then adapting the Syphon, as before, we wish'd for a happy event in the Experiment. But Experience (which ought to be the
Mistress

Mistress of wise men as well as fools) shew'd us the quite contrary; for the Syphon would not run at all, but continued full, which we afterwards conjectured to proceed from the *Heterogeneity* of the two Liquors. so that the Oyl of *Tartar* would not break out into the Spirit of Wine, no more than Milk or Water will do into the open Ayr, where the pendent Shank is shorter than the Standard-height of those two Liquors. So that, it seems, to effect this Experiment indeed, two such Liquors must be found out, as are in some wise *Homogeneous*, and of a Congruity, and the one considerably lighter than the other, which is *tantum non impossibile*. For besides the former Liquors, we have tried Oyl and Water, and no Motion at all was perceived, for the same reason of incongruity formerly delivered.

But these, and a hundred more Experiments of this nature are every day excogitated and tried by our Noble Society of *Gresham-Colledge*, which in a little time will be improved into far nobler Consequences and Theories, than can possibly be done by the single Endeavours of any Person whatsoever.

The End of the *Mercurial Experiments.*



EXPERIMENTAL
PHILOSOPHY.

The Third Book.

Containing
Experiments Magnetical :

With a Confutation of

GRANDAMICUS.

Amicus, *Plato* ;

Amicus, *Aristoteles* ;

Grandis Amicus, *Grandamicus* :

Sed, Magis Amica, Veritas.

By HENRY POWER, D^r. of Physick.

LONDON,

Printed in the Year 1663.

THE HISTORY OF

THE CITY OF

NEW YORK

FROM THE FIRST SETTLEMENT

TO THE PRESENT TIME

BY J. VAN DER LINDEN
OF THE CITY OF NEW YORK
AND
J. VAN DER LINDEN
OF THE CITY OF NEW YORK

NEW YORK: PRINTED BY J. VAN DER LINDEN

1794



A CONFUTATION

OF

GRANDAMICUS

HIS

MAGNETICAL TRACTATE,

DE

IMMOBILITATE TERRÆ.

The Third Book.

CHAP. I.



He three great Demonstrations and Magnetical Discoveries that this Authour so gloriously pretends to, are

1. A Magnetical Demonstration of the Earth's Immobility.
2. An universal Meridian Magnetically demonstrated.
3. A

X

3. A Magnetical discovery of Longitudes, or something equivalent thereunto.

In the canvassing of these three great Discoveries, we shall invert the order, and begin with the last first. But before we can conveniently fasten upon these three main pillars of his Book, there are three other considerable Errors of his, first to be removed; which, though they lye more obscure and removed from our sight, and buried, as it were, under ground; yet indeed are they the Basis and Foundation upon which his magnificent Structure is built: And they are these Positions following:

1. That the virtue of the Magnet, and all Magnetick Bodies, is purely immaterial, and a bare simple Quality.

2. That it proceeds intrinsically from the proper form of the Loadstone; as he hath delivered, *Cap. 3. Pag. 48.*

3. That all the World, and consequently all the Bodies therein, were made, by the Divine Providence, for the use of us and our habitation, this Globe of Earth; which he has fixed in the Centre of the World, and constituted us Lords and Masters of all the Universe. *Grand. Pag. 50.*

CHAP. II.

Of the Corporeal Effluviiums of the Loadstone.

DOCTOR *Highmore* tells us, That the Magnetical Exspirations of the Loadstone may be discovered by the

the help of Glasses, and be seen in the form of a mist, to flow from the Loadstone: This, indeed, would be an incomparable eviſtion of the Corporeity of Magneticall Effluvi-
ums, and ſenſibly decide the Controverſie under Conſideration. But I am ſure he had either better Eyes, or elſe better Glasses than ever I ſaw (though I have look'd through as good as *England* affords) and the beſt of them all was as far from preſenting theſe ſubtil Emanations, that they would never exhibit to me thoſe groſſer, and far more material, Effluvi-
ums, from Electrical and Aromaticall Bodies: Nay, not the Evaporations of Camphire, which ſpends it ſelf by continually Effluviating its own component Particles: Nay, I could never ſee the groſſer ſteams, that continually tranſpire out of our own Bodies, and are the fuliginous Eruſtations of that internal Fire which conſtantly burns within us. Indeed, if our Dioptricks could attain to that Curioſity, as to grind us ſuch Glasses as would preſent the Effluvi-
ums of the Magnet; we might hope to diſcover all *Epicurus* his Atoms, *Des-Cartes* his *Globuli ætherii*, and all thoſe inſenſible Corpufcles which daily produce ſuch Conſiderable effects in the generation and corruption of Bodies about us: Nay, might not ſuch *Microscopes* hazard the diſcovery of the Aerial *Genii*, and preſent even Spiritualities themſelves to our view? But though both our Natural and Artificial Eyes fail in this performance, yet have we another more Intrinſick Eye, that will yet diſcover their materiality, and that is the piercing Eye of Reaſon. For,

I. That the Magnetical Emiſſions and Fluors, are not bare Qualities, but indeed Corporeal Atoms, is deducible from hence; That this virtue decays in progreſs of Time (as all Odours do) and is totally de-

stroy'd by Fire in a few minutes, and is capable of Rarity and Density, whence it is more potent near at hand than further off: all which are the proper and incommunicable Attributes of Bodies.

2. Again, it is further evinced by some Parallel and Analogical effects of Electrical with Magnetical Bodies, that they both work by Corporeal Effluvia; for a well polish'd stick of hard Wax (immediately after friction) will almost as vigorously move the Directory Needle, as the Loadstone it self; onely there is (amongst others) these considerable differences 'twixt these Eminent Bodies, that the Effluvia of the one, (as being more Gross and Corporeal) are intercepted by any medium; but Magnetical Effluvia are hindered (because of their exceeding tenuity) by the interposition of no Body whatsoever. Secondly, Whereas Electrical fluors do presently recoil by short streight lines to their Bodies again, Magnetical Atoms do not so; but do wheel about, and, by a Vortical motion, do make their return unto the Loadstone again, as *Des-Cartes* hath excellently declared.

CHAP. III.

That the Magnetical Effluviiums do not proceed intrinsecally from the Stone, but are certain extrinsecal particles, which approaching to the Stone, and finding congruous pores and inlets therein, are channel'd through it; and having acquired a Motion thereby, do continue their Current so far, till being repulsed by the ambient Ayr, they recoil again, and return in a Vortical Motion, and so continue their revolution for ever, through the Body of the Magnet.

Argument I.

THIS seems probable, first, from this, That if a Magnet it self be made red hot in the fire, it not onely amits the Magnetical vigour it had in it self before, but acquires a new one, according to the positional Laws in its Refrigeration; so that by inverting the Extremes (as it came out of the fire) you may alter the Poles thereof (at pleasure,) nay, you may change the Polarity of many feeble

feeble Stones, by a long Position, in a contrary posture to that which it naturally affects. Both which Experiments seem to shew, That the Magnetical Effluvia are not Innate and Congenial to the Stone, but proceed *ab extrinseco, &c.* therefore do impregnate the Stone again, upon their re-admission; or do change its Polarity, as the more powerful streams of Atoms do prevail. The like Experiment (if it could be tried) would doubtless hold good in the great Magnet of the Earth; for the *Terrella* we see in all other *Phænomena*, is avouched by her Mother-Earth.

Argument 2. The said Argument we may assume from a certain Section of the Stone; for if you divide the Magnet through a meridian, or Saw of a Segment, parallel to the Axis, the former Axis and Poles will quite vanish away; and each Segment, by this division, will acquire a new Axis of its own: which shews, That the external Magnetical Fluors, which pass'd through the Stone, all in one continued stream before, now passe by several currents through both Stones, and so create a new Axis and Poles in either.

Argument 3. Is from the disponent or directive faculty (as they call it) of the Stone; for to say, This Polarity direction proceeds from it self, is to put a Soul, or Intelligence, at least, into the Stone; which must turn it about (as Angels are fained to do the Coelestial Orbs:) How much more credible is it, That the stream of Atoms from without, by beating upon the Stone, do turn it to and fro, till they have laid it in such a Position as is fittest for them to run through it, as a stream of water turns a hollow trunk of wood, or a long stick, till it come to lye parallel to its current.

Argu-

Argument 4. Is from the different effects proceeding from all Effluxions that come from all other Bodies, besides Magnetical, as Electrical, Odoriferous, &c. for all Bodies that effluviates intrinsically from themselves, their exspirations flye quite away into the open Ayr, and never make any return again to the Body from whence they proceeded, so that in time they do not onely spend their quintessential and finer particles, but even their whole bulk and substance, as is Ocularly manifest in Camphire: Now 'tis not so in Magnetical Bodies, whose exspirations are continual and permanent, because they return in Circumgyrations to their Bodies again.

Argument 5. If the Magnetick rayes proceeded intrinsically from the Stone, there is most reason they should proceed from the Centre, the Stone being all of an uniform Substance; as the Luminous rayes doe from the Body of the Sun, and as Odours do from their Original; and so there would be no Poles, nor Inclinations of Magnets more in one Latitude than in another: But now since there are two Poles, where the Current of Effluxions are strongest, it is a sign the Magnetical Fluors coming from without, doe strike a stream in at one Pole; and finding the grain and bait of the Stone, to lye fit for their Tranation, do channel through to the opposite part of the Stone, and so continue their Current in the Ayr, so far, till they are resisted and forced to recoil by a double whirlpool-motion round about into the Magnet again.

Argument 6. That the Magnetick Fluors proceed not intrinsically from the Stone, to cause the Self-Direction in the Magnet, is further evident from this new
Expe-

Magnetical Experiments.

Experiment: Take a wedge of Iron (which the Smiths call Puncheons) and heating it red-hot, you shall, according to the Laws in its refrigeration, endue it with a polary verticity, as has been præobserved by all Magnetick Writers: But that which will heighten the Experiment further, is, That though it hath but acquired a feeble virtue by its refrigeration, yet if you take it up cold, and with a few smart strokes of a great Mall, or Hammer, you beat the one end of it, setting the other against some hard resisting matter, as Stone, Brass, Iron, or hard Wood, you shall thereby give it a most powerful Magnetisme, so that it will then as actively move the Needle, at a good distance, as the Loadstone it self: Now, say I, by those percussions you did so open and relax the pores in the Iron wedge, that the Magnetical Atoms could then enter in, with a full Carriere, which before they could not; and having once got so free a passage, they will maintein the Current ever after.

Argument 7. Since a constant, steddy, and polary direction of parts is onely observable in Bodies Magnetical, we have reason to think and believe, that these Magnetical *Effluvia* (which are the cause of this peculiar direction) are not only transmitted and channel'd through the Earth, but through many other Cœlestial Bodies also, as ☉ ☿ ♀ ♄ ♀, and, perchance, the rest of the Planets yea and Fixed Stars too, as by *Telescopical Observations* is now made very manifest in those Bodies that swim within our Planetary Systeme.

Argument 8. Take a Rod of Iron (or a Puncheon) as before; heat it red-hot, and according to the Laws in its refrigeration, you may endue this or that Extreme
with

with whether polarity you please ; now afterwards by striking it with a Hammer in the same posture that it was cooled in, you may much advance and invigorate its Magnetical virtue, as we have formerly declared : But now the main Observable of all, is, That after both the reception of the virtue by convenient refrigeration, as also the augmentation of it by percussion, you may by inverting and repercussing the Extremes, alter the polarity of the Iron at your pleasure; and then, which is stranger, that if you strike the Iron in the middle 'twixt the two Extremes, it will destroy its formerly acquired Magnetism.

Argument 9. If you bore with a Wimble in any hard piece of wood, till you heat it soundly, you will communicate to it a strong Verticity, insomuch that it will nimbly turn a Magnetical Needle ; but if with a drill of Iron or Steel you bore a piece of Brass or Iron till you heat it well, it will acquire so strong a Magnetism thereby, that it will not only turn an equilibrated Needle, but vigorously attract, and lift up a small Needle: and I have observed the small filings and shavings which fall out of the Drill-hole, to stick to the point of the Drill, as if it had been to a Magnet it self ; which shews, that the Magnetical Atoms did more easily by far enter into the Drill or Wimble, when the parts thereof were heat and set in Motion, than before.

Which still seems to make out, That the Magnetical Atoms rather enter into, than proceed from those Bodies we call Magnetical, as the reaching soul of the renowned *Des-Cartes* hath happily supposed.

CHAP. IV.

*That the World was not made Primarily,
nor Solely for the use of Man, nor in
Subserviency unto Him and his Faculties.*

AS I would not derogate from the Greatness and Eminency of Man (as being a very Noble Creature;) so I would not have him arrogate too much to himself: For though it may be a pious, and morally good conception, To think that the whole world was made for him, yet I am sure 'tis no real and Physical Truth.

For first, How many glorious Bodies of vast Bulks, and immense Distances, have appeared, nay, and may yet appear to future ages (as Comets and New Stars) which are now gone and vanish'd again, which no mortal man ever understood the reasons and causes of, nor received no good nor evil, either before or since their appearances? Nay, How many such Comets may have been near the Sun, whose first rise, continuation, and disappearance may have been made in six moneths time, of which (by reason of the Sun's vicinity to them) we could never see nor know any thing? Who can be so irrational, as to think that those innumerable company of Stars (with which the *Via Lactea* is powdered) and many other parts of Heaven are throng'd (as the *Pleades*) in which very Subconstellation I have seen above 20, Stars of a considerable Magnitude, and lesser ones
innume-

innumerable, also the *Hyades*, the *Stellæ Nebulose*, &c. were ever made for the use of Us and our Earth, since they are at that immense distance, and invisible to our eyes; and had remain'd eternally so, had not the incomparable invention of *Telescopes* relieved our eye-sight herein? Nay, to come nearer, Who can imagine that any of the primary Planets were wholly designed for the service of Us and our Earth; whereas, if most of them were pluck'd out of the Heavens, we should no more feel the want of them, than the Countrey Swain that already knows of no such Wanderers? What then must we think of the Secondary Planets, as the Circum-Saturnian, and the four Jovialists, which are not onely indiscernable by us, and therefore were never designed for our use, but also have their peculiar Motion about their Primary Planets (which they orderly and punctually attend) which shews other ends that God and Nature has designed them for, to wit, to be as wholly Subservient to their Central Planets of *Saturn* and *Jupiter*, as the *Moon* is to us? Lastly, Who is there that knows not the vast disproportion 'twixt this Speck of Earth, and the immense Heavens, how that it is less than the smallest Mote or Atom, which we see to hover and play in the Sun's beams, in comparison of the Fixed Stars? So that if one stood but in the Firmament, it could never be seen at all; and if it were annihilated, would never be miss'd, being so small and inconsiderable a portion of the Creation: Nay, our Modern Philosophers have found, That not onely the Earth, but the whole *Orbis Magnus* (which is the Earth's Annual Circle it describes about the Sun) is but a Point, in regard of the immense distance of the Fixed Stars. Nay, the Noble and Elastic Soul of *Des-Cartes*, that has stretch'd it self yet a

pin higher, has done the Heavens and Upper World more right yet, as to the Magnificent vastness of its Expansion, and has shown us that every Fixed Star is a Sun, and is set in the Centre of a *Vortex*, or Planetary System, as ours is, and that they are as far remote one off another, as ours is off them; and that all our whole Planetary *Vortex* shrinks almost into nothing, if compared to those innumerable Systems above us. What are we then but like so many Ants or Pismires, that toyl upon this Mole-hill, and could appear no otherwayes at distance, but as those poor Animals, the Mites, do to us through a good *Microscope*, in a piece of Cheese?

Let us not therefore pride our selves too much in the Lordship of the whole Universe, 'tis more, I am sure, than we could challenge from our Creatour, that he hath made us such Noble Creatures as we are, that he hath given us such a large Inheritance, as the whole Globe of the Earth, that he hath Subjugated all things therein to our use and service; and lastly, that he hath endued our Souls with such spiritual and prying faculties, that we can attempt and reach at the Superiour and more mysterious works of his Creation, and therein to admire those things we are not capable to understand. As for the Earth being the Centre of the World, 'tis now an opinion so generally exploded, that I need not trouble you nor my self with it. And, indeed, what need I take pains to refute that which is but *gratis dictum*, and which he neither hath, nor all the Peripateticks in the world can ever prove. Let us first see him do that, and then you shall see what I am able to say to it.

C H A P. V.

AND now I come to his three great Inventions ; and the first shall be of *Longitudes*. To find the Longitude of any place, or some thing æquipollent thereunto, is easily done (saith he) from these three *Data* ; that is,

The Angle of { *Magnetical Inclination.*
Magnetical Variation.
Elevation of the Pole.

As for Example: At *Rouen* in *France*, The Angle of North-Easting Variation of the Compass is — 2 gr. 30'.
 The Angle of Septentrional Inclination is — 72 gr.
 The Elevation of the North-Pole there, is — 49 gr.

Grandamicus his Consequence from hence.

Now 'tis impossible (saith he) that these three Angles should be the same in any other determinate point of the Earth, but at our City at *Rouen*.

To which we Reply,

First, That he runs upon a false Assumption ; viz. That the Angle of Variation it self is perpetually the same in the same place of the Earth, which is false ; For Mr. *Burrows*, *Ann. Dom.* 1580. made an exact Observation of the Needle's Variation towards the East at *Lime-House*,

House, near *London*, and found it to amount to no less than 11 gr. 15', and afterwards, *Ann. Dom.* 1622. Mr. *Gunter*, at the same place, observed it to be diminished to onely 6 gr. and 13'. And *Gildebrand*, *Ann. Dom.* 1634. in the same place found it to come yet lower, and not to exceed 4 gr. 6 min. So that in process of time it is very probable it will come to an exact Meridionalit^y, and, perchance veer as much on the other side of the Meridian Line (*viz*) Westwards, as it hath done of this.

Doctor *Croone*, my Worthy and most Ingenious Friend, writes me word, that in *June* last, 1661. the Magnetical Variation at *London*, was found to be by the best Observation 45' 30" Westwards: so that it seems it has past the Meridian already. And of this mystery of the Variation of the Variation, *Grandamicus* himself was not ignorant; but because it would spoyle his glorious Invention, he therefore unhandfomly and unworthily asperges our *English* Observations, with Ignorance, Error, and Incertitude, *cap.* 4. *pag.* 73.

Whereas the Observators nominated, were of that Knowledge and Perspicacity in the Mathematicks, that I am sure 'tis a Credit to *Grandamicus* to be inferiour to any of them. But we shall now tell him, That not onely the *English*, but his own Countrey-men have found out this truth. So that the like decrease of the Needle's Variation has been observed at *Paris* by *Mersennus*, and at *Aix* by *Gassendus*: So then this Angle of Variation being quite fallible, and alwayes variable, his other two Angles will prove nothing at all; for they are the same in the same Latitude or Parallel round about the Earth.

2. But granting him his three *Data*: I say, in the opposite point of the Globe (that is *Antipodes* to *Rouen*) all these three Angles are the same.

If

If you reply, and say, That though the Angles of Variation and Inclination be the same, yet they will be pointed out by the opposite points of the Directory and Inclinary Needles. To which we Counter-reply, That the same point of the Needle that pointed at the North-pole here, will there point at the South-pole; therefore he can have no evidence of the Needle of Variation, as is manifest by carrying the Needle from the one Pole of the *Terrella* to the other.

And for the Inclinary Needle, we see what a ticklish thing it is to make exactly, and though it be poized by a good Artificer, yet will it miss one or more Degrees in hitting the true point of Inclination, which would be a considerable Error, to a Land-Traveller at least.

3. For the Profit and Utility of this Invention, 'tis none at all: for to a Traveller that sails in one and the same Parallel (which he may do many a thousand miles) the Angles of Inclination and Elevation will remain the same with those at the Port from whence he set Sail; and though the Angle of Variation did alter (as he would have it) yet my Marriner can tell nothing at all thereby, but onely thus, That he is not at *Rouen*; but how far he is gone from it, either East or West, he knowes not at all; unless he foreknew the Angles of Variation in every Longitude, which is yet unknown: and if they were all now known, yet were it of little or no use or benefit, because in process of time the Variation it self varies, as we have pre-observed.

CHAP. VI.

AND now we come to his Second great Invention, with which he thunders against the *Copernicans*, and that is his great Magnetical Experiment to avouch the Earth's Immobability.

To this Experiment therefore drawn from the perpendicular position of the Magnet, we answer, That the reason why the *Terrella* does wheel about, and direct certain parts of its *Æquator*, to certain and determinate points of the Horizon, is, Because it is overpower'd by the Magnetical Effluxions of the Earth; which, as a greater Magnet, does violently reduce it to that Situation, which probably is the same that those *Æquatorial* parts had in their Mineral Beds : And therefore this great Argument against the Diurnal Motion of the Earth, is no Argument at all, unless that he could prove to us that the *Terrella* could play this trick; it were removed out of the sphere of the Earth's Magnetisme, which is beyond his Philosophy ever to demonstrate.

2. Again, If this Motion of the Magnet did proceed from an Intrinsic Tendency that it has of its own, to bring all its parts to their right and determinate points, there to remain in a perfect Stability, then would those parts constantly affect this (and no other) Situation, howsoever the Loadstone was posited (provided it be at Liberty to move it self to its desired position.) But this is false; For, in *Grandamicus* his Experiment, if you invert the Poles of the Magnet, and set the North-Pole in the Zenith, and the South in the Nadir, you shall see the Stone to Counterchange its Situation, and those æquatorial

torial parts of the Magnet, which before respected the East, shall now wheel about, and fix themselves in the West; and the Northern parts turn to the South: which shews, That the Stone does not Tack about from an intrinsecal principle and form of its own, but is turned by the extrinsecal Effluxions of the whole Earth; or rather by the stream of those Magnetical Atoms, that strike not onely through the Axis of the Earth, but also through the Body of every petty Loadstone, accordingly as they are best received by the Grain or Bait of the said Stone.

And now I am engaged in this Magnetick Discourse, I must tell you that I think our famous *Gilbert* has drawn a more prevalent Argument from this Magnetical Philosophy, to prove the Earth's Motion by, than *Grandamicus* has done to destroy it; for since it is demonstrated of late, that all the whole Earth is nothing but a great and Globular Loadstone, and that all the Circles of the Armillary Sphære, are really, truly, and naturally inhærent in the Earth, by virtue of the transcurrent Atoms, How can we conclude otherwise but with *Gilbert*? *Quis in posterum eum de factis moveri dubitabit, quum ei omnia ad motum planè requisita, dedit natura; i. e. figuram rotundam, pendulam in medio Fluido positionem, & omnes terminos motui Circulari inservientes, polos nempe, æquatorem, meridianos & polares circulos, & parallelos?*

Lastly, As for his Universal Meridian, it is likewise deduced from his Anti-Copernican Experiment of the Loadstone swimming in a Boat, with its Poles vertically erected: For (saith he,) Since the Stone being Horizontally placed, does not shew the true Meridian, but with an Angle of Variation, in most, if not in all places of the Earth, if you set it with its Axis perpendicular as before, it will (after some undulations to and fro) rest quietly,

Z

with

Magnetical Experiments.

with certain parts facing the Meridian; which points must be exactly marked, and through them a Circle drawn round about the Stone; by help of which, you may strike a true Meridian-Line, when and where you please.

Now, though we grant this Experiment to be true, and, probably, to hold good in all Longitudes and Latitudes; yet he that shall perpend, how many ticklish Curiosities, and nice Circumstances there are to perform this Experiment exactly, will find the Invention only pleasing in the Theory, but not in the Practice: For, 1. It is very difficult to place the *Terrella* in an exact perpendicular; 2. When 'tis so, 'tis as difficult to keep it invariable under the same Zenith; 3. Most difficult to draw an exact Meridian-Line from it: Not to mention how hard a thing it is; first, to find the two Polary points in a Globe-Loadstone; also to keep the Boat in a Fluctuation, parallel to the Horizon.

The end of Magnetical Experiments.



Subterraneous Experiments :

OR,

OBSERVATIONS

About

COLE-MINES.

BY

HENRY POWER, M^x. D^r.



A The Cole-pit.

B The Vent-pit.

C C The Sow, that drains all the heads from water.

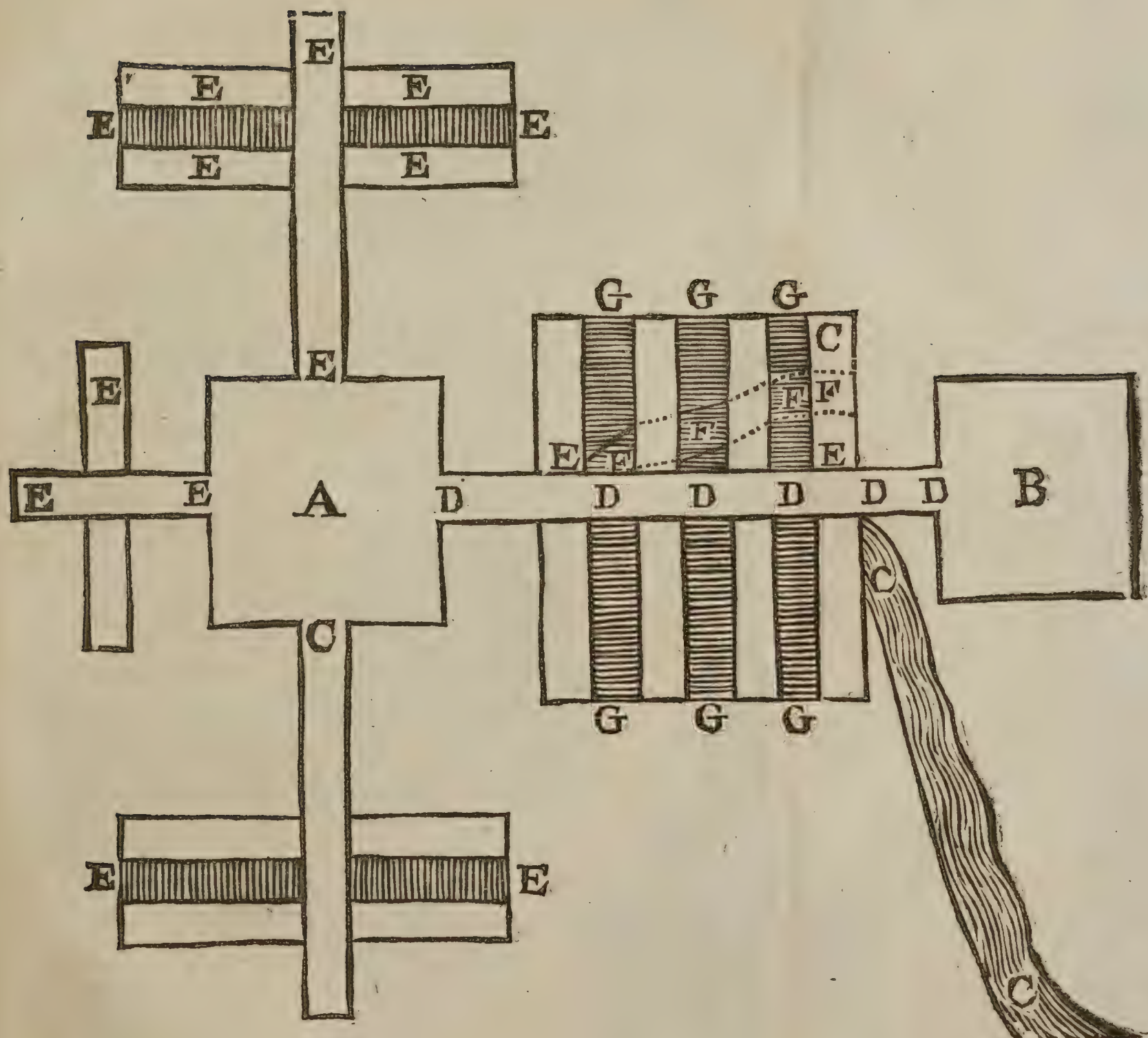
DDD, &c. The Vent-head, not above two yards broad.

EEEE The Lateral Heads, which are not above two yards broad.

F F F The prick'd lines, the Thurl-vent; that is, a Vent driven through the lateral heads.

G G G G Is Walls or Pillars of the whole Cole-Bed remaining (which with us is not above two foot thick) to hinder the roof of the pit for falling.

The Roof and Seat is the Top and Bottom of the Works, wherein they get Coles, which is about two foot or more distant the one from the other.

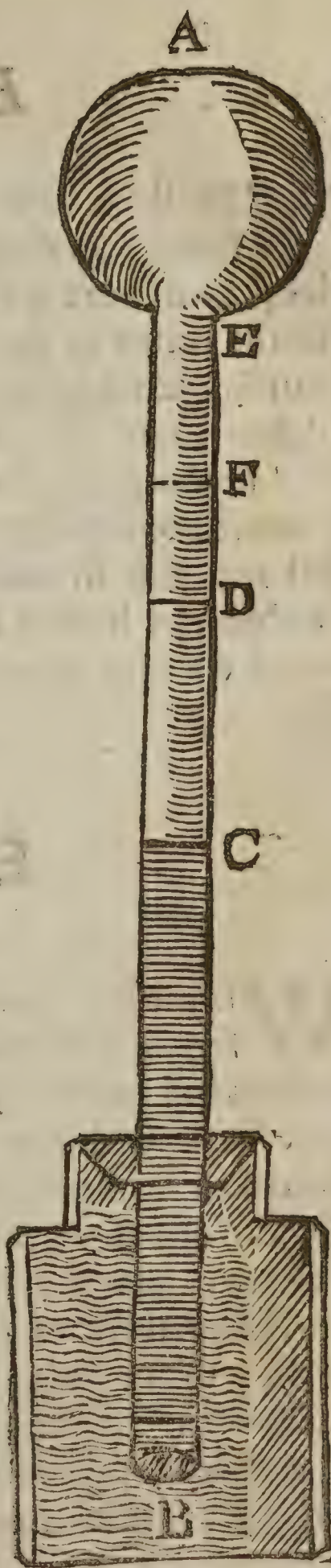




Experiment I.

AT the top of the Cole-pit we took the Weather-Glass A B, whose shank E B was about $2\frac{1}{2}$ foot long, of a small bore, and the Head A $2\frac{1}{4}$ inches in Diameter; and heating the Head thereof, and immersing it presently in the Glass full of water B; the water, after a competent time, rose up to the point C; where we let it stand for a while, till we saw that the External and Internal Air were come to the same Temper and Elasticity.

Then carrying the Weather-Glass (so prepared) in a Scoop down to the bottom of the Cole-pit (which was not above 35. yards deep) there the Water in the Weather-Glass did rise up to the point D, viz. very near 3. Inches higher than its former Standard C.



Experiment.

Experiment 2.

THe sixth day of *November*, 1662. we repeated the same Experiment, as before, in a pit of 68. yards deep, and there we found, that at the bottom of the said pit the water in the Weather-Glasse, did rise very near four inches higher than the point C: *viz.* one inch higher than the point D to F. Now we observ'd, that in carrying down of the said Glass in a Scoop from the top to the middle of the Pit, there the water did not rise so much as it did from the middle to the bottom, by half an inch; so that it seems the rise of the water was not proportional to the Glasse's descent in the Pit.

Experiment 3.

WE took a very good arm'd Loadstone, of an Oval figure (whose poles lay in the long Diameter) and at the top of the Coal-pit we loaded the North-pole of it with the greatest weight it was able to carry, even to a Scruple; then taking the Stone down to the bottom of the pit, and hanging on the same weight again, we could perceive no difference in the power of the Stone at the one place from the other; for it would neither lift more nor less there, than above: though to try this Experiment precisely, and to minute weights, is very ticklish; for the same Stone in any place will sometimes lift a little more, and sometimes a little less.

Experiment

Experiment 4.

WE took a thread of 68. yards long (which is as long as the deepest pit is with us) and fastening a Brass lump of an exact pound weight to it, we counterpoiz'd both it and the thread with a weight in the other Scale ; then fastning the other end of the thread to one of the Scales, we let down the pendent weight near to the bottom, and there we found it to weigh lighter by an ounce at least than it did at the top of the said pit.

We had tryed this with a Bladder full of water, and other substances also, but that our thread by often untwining broke it self.

Experiment 5.

THE Collyers tell us, That if a Pistol be shot off in a head remote from the eye of a pit, it will give but a little report, or rather a sudden thump, like a Gun shot off at a great distance ; but if it be discharg'd at the eye of the pit in the bottom, it will make a greater noise than if shot off above-ground. But these Experiments are of a dangerous trial in our pits, and the Collyers dare not attempt them by reason of the craziness of the roof of their works, which often falls in of its own accord without any Concussion at all.

Every Cole-pit hath its Vent-pit digg'd down at a competent distance from it, as 50. or 80. paces one from another.

A a

They

They dig a Vault under-ground from one pit to another (which they call the Vent-pit) that the Ayr may have a free passage from the one pit to the other; so that both pits with that Subterraneous intercourse, or vault, do exactly represent a Syphon invers'd. Now the Ayr always has a Motion, and runs in a stream from one pit to the other; for if the Ayr should have no Motion (or Vent, as they call it) but Restagnate, then they could not work in the pits.

It is not requisite that the Vent-pit should be as deep as the Cole-pit.

Now the Vent, or Current, of Subterraneous Ayr is sometimes one way, and sometimes another; sometimes from the Vent-pit to the Cole-pit, and sometimes contrariwise (as the Winds (above ground) do alter;) and also weaker and stronger at sometimes than at others: and sometimes the Vent plays so weakly, that they cannot work for want of Ventilation.

Then to gather Vent (as they call it) they straiten the Vault, and wall part of it up; so that the Ayr (which before run in a large stream) being now crowded into a lesser channel, and forced to pass through a narrower room, gathers in strength, and runs more swiftly.

Now it is observ'd, that the Subterraneous Ayr is alwayes warm, and in the coldest weather, the warmest; so that it never freezes in that pit, out of which the Vent plays.

Of Damps.

There are three sorts of Damps, or rather three degrees of the same Damp;

Viz. { The Common.
The Suffocating.
The Fiery.

The Common Damp is that Subterraneous Steam, or Exhalation, which coming out of the Earth, restagnates in the heads and undergroundy-cavities, and hinders their Candles for burning, so that they cannot work.

1. If they incline their Candle downwards, towards their seat, it is observ'd, it will abide in the longer, and not sweal away, and stifle it self with too much tallow, as it would do above-ground.

2. Though this Damp be so great, as it extinguishes the Candle, yet they can abide in it without Suffocation. Also the heavy vapour will restagnate there, and is not able to rise.

3. This Damp is sometimes generated by the Effluvia and Perspirations that come out of their own Bodies that work, if they sweat much; and if the Candle be within the sphere of those Effluvia, it will extinguish it as the former; as the Collyers observe that pass from one head to another that is working in another head.

This Damp is sometimes on the one side of the heads and not on the other; and for the most part it runs all along the roof, so that a Candle will burn, if set upon the seat: but if you lift it up into the superincumbent

Region of Damp-vapours, it will be immediately extinguish'd.

Now besides the playing of the Vent, they sometimes are necessitated to keep constant fires under-ground, to purifie and ventilate the Ayr: Sometimes the running of the Scoops (when they begin to work) will set it into Motion: Sometimes, if the Damp draw towards the eye of the pit, then they set it into Motion by throwing down of Cole-sacks.

Of the Suffocating Damp.

THE Suffocating or Choking Damp is a more pernicious Exhalation, or else a higher degree of the former; into which no man is able to enter, but presently he is stifled and dyes. And it is observed, that the Bodies of those (which are so slain) do swell, and are puffed up exceedingly, as if poyson'd. This Damp is seldom here in our pits; but if it be, then the first person that is let down into it, is presently kill'd: so that afterwards they try, by letting down dogs, when it is removed, and fit to enter into; and most-part by letting down of lighted Candles, which will be extinguish'd by the Damp in the bottom of the pit, if any Damp be restagnant there.

Of the Fiery Damp.

THE Fiery Damp is of all others the most dangerous, but is never seen in our pits, though in pits at *Leeds*, which is not above 12. miles off, as also in the *Lancashire* pits, and *Newcastle* pits, I have heard much of it.

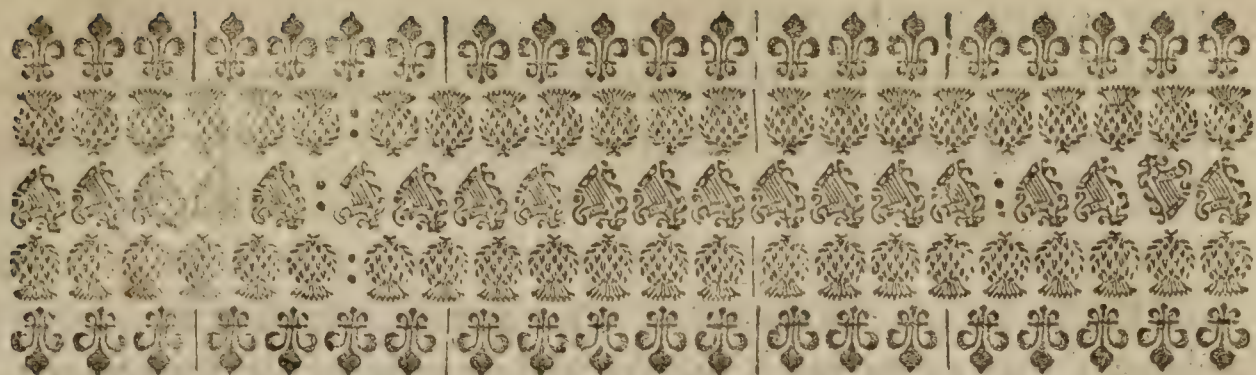
It is a Vapour, or Exhalation, which comes out of the Mineral, or out of the clifts in the Mineral, and it sometimes comes out Fired, and sometimes in the form of a Smoke, which afterwards fires of its own accord, and then forces its way with that vehemence and activity, that it drives all away before it, and kils without mercy; infomuch that I have heard, that not many years ago, three men in *Newcastle*-pits were fo shattered with it, that their very limbs were fever'd.

This Fiery Meteor is observ'd to run all along the roof of the pit, fo that if the Collyers have the fortune to fee it iffuing out, there is no way to fecure themselves, but to lye flat along to the feat of the pit, and fo do sometimes escape fo great a danger. Sometimes it has taken its way up at the pit-eye, or shaft, with fuch vehemency, that it has thrown the Turn quite away from the mouth of the pit, which is a Cylinder of wood of a great weight, and has burnt and findg'd the Rope, as black as Lightning does Trees.

This is that Meteor, certainly, that *Paracelsus* calls the Corufcation of Metals, which, he faves, is a fign of Metals in that place; and, doubtless, is it that occasions Earthquakes, whensoever it happens in any quantity, and can have no Vent.

The end of Subterraneous Experiments.

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The Conclusion.

*To the generous VIRTUOSI,
and Lovers of Experimental Phi-
losophy.*



Certainly this World was made not onely to be Inhabited, but Studied and Contemplated by Man; and, How few are there in the World that perform this homage due to their Creator? Who, though he hath disclaimed all Brutal, yet still accepts of a Rational Sacrifice; 'tis a Tribute we ought to pay him for being men, for it is Reason that transpeciates our Natures, and makes us little lower than the Angels: Without the right management of this Faculty, we do not so much in our kind as Beasts do in theirs, who justly obey the prescript of their Natures, and live up to the height of that instinct that Providence hath given them. But, alas,
How

How many Souls are there, that never come to act beyond that of the gazing-Monarch's? *Humanum paucis vivit genus*. There is a world of People indeed, and but a few Men in it; mankind is but preserv'd in a few Individuals; the greatest part of Humanity is lost in Earth, and their Souls so fixed in that grosser moiety of themselves (their Bodies) that nothing can volatilize them, and set their Reasons at Liberty. The numerous Rabble that seem to have the Signatures of Man in their faces, are Brutes in their understanding, and have nothing of the nobler part that should denominate their Essences; 'tis by the favour of a Metaphor we call them Men, for at the best they are but *Des-Cartes's Automata*, or *Aristotle's* μηχαναὶ ἀνδρωεινὸς ζῶντος, but the moving frames, and Zanies of men, and have nothing but their outsides to justify their titles to Rationality.

Pugs and *Babeons* may claim a Traduction from *Adam* as well as these, and have as great a share of Reason to justify their Parentage.

But it is not this numerous piece of Monstrosity (the Multitude onely) that are enemies to themselves and Learning; there is a company of men amongst the Philosophers themselves, a sort of Notional heads, whose ignorance (though varnish'd over with a little squabbling Sophistry) is as great and invincible as the former. These are they that daily stuff our Libraries with their Philosophical Romances, and glut the Press with their Canting Loquacities. For, instead of solid and Experimental Philosophy, it has been held accomplishment enough to graduate a Student, if he could but stiffly wrangle out a vexatious dispute of some odd Peripatetick qualities, or the like; which (if translated into *English*) signified no more than a Heat 'twixt two Oyster-wives in *Billingsgate*:

gate : Nay, these crimes have not onely stain'd the Common, but there are spots also to be seen even in the Purple Gowns of Learning. For it hath been a great fault, and, indeed, a solemn piece of Folly, even amongst the Professors and nobler sort of Philosophers, That when they have arrived to a competent height in any Art or Science, if any difficulty do arise that their Art cannot presently reach unto, they instantly pronounce it a thing impossible to be done ; which inconsiderable and rash censure and forestallment of their endeavours, does not onely stifle their own further Enquiries, but also hangs, to all succeeding ages, as a Scar-crow to affright them for ever approaching that difficulty. Hence it is, that most Arts and Sciences are branded at this day with some such ignominious Impossibility.

Thus came they to upbraid Chymistry with the Alchymest, and Philosophers-Stone ; Geography, with Longitudes ; Geometry, with the Quadrature of a Circle ; Stereometry, with the Duplication of the Cube ; Trigonometry, with the Trisection of an Angle ; Algebra, with the *Æ*quation of three discontinued Numbers ; Mechanics, with a Perpetual Motion ; and our own Profession, with the incurability of Cancers and Quartans. Nay, the Spring and Neptides in Natural Philosophy, the Doctrine of Comets in Astronomy, the Terra Incognita in Geography, the Heart's Motion in Anatomy, the Forming of Conick Sections in Dioptricks, the Various Variation in Magnetical Philosophy, are accounted as insuperable difficulties as the former, whose Causes (they say) defie all Humane Industry ever to discover them.

But besides this Intestine war, and civil dissention that is 'twixt men of the same denomination and principles,

there is one more general Impediment, which is an Authentick discouragement to the promotion of the Arts and Sciences, and that is, The Universal Exclamation of the World's decay and approximation to its period; That both the great and little World have long since pass'd the Meridian, and, That the Faculties of the one doe fade and decay, as well as the Fabricks and Materials of the other; which though it be a Conceit that hath possess'd all ages past, as nearly as ours, yet the Clamour was never so high as it is now: Something, therefore, I shall here offer, that will abate and qualifie the rigour of this Conception.

*An Essay, to prove the World's Duration,
from the slow motion of the Sun's Apo-
gæum, or the Earth's Aphelion.*

First, We take for granted, from the Scripture-Account, that the World is about 5000. years old.

Secondly, We take it for granted, that the Sun's *Apo-
gæum* was at the Creation set in the first point of *Aries*; for which you will anon see prevalent reasons.

Thirdly, From Astronomical Observation 'tis now found, that the Sun's *Apogæum* is about the sixth degree of *Cancer*.

Fourthly, By intervals of Observation it is likewise found, That the Motion of the Sun's *Apogæum*, in 100. years, is 1 gr. 42' 33", which by retrocalculation will point out the time of the World's Nativity to be about 5000. years ago, which very handsomely draws nigh to the

the Scripture-Account, as the famous *Longomontanus* has ingeniously observed.

Now in all likelihood, he that made this great Automaton of the world, will not destroy it, till the slowest Motion therein has made one Revolution.

For would it not even in a common Watchmaker (that has made a curious Watch for some Gentleman or other, to shew him the rarity of his Art) be great indiscretion, and a most imprudent act, and argue also a dislike of his own work, to pluck the said Watch in pieces before every wheel therein had made one revolution at least? Now the *Apogæum* (if it move equally, as it hath hitherto done) will not perfect one Revolution under 20000. years, whereof there is but one Quadrant yet spent, and 15000. years are yet to come.

Besides, What reason is there that God should respect the one Hemisphære of the Earth, more than the other? For, take the Sun's *Apogæum* now as it is, and the North Hemisphære of the Earth hath eight days more of the Sun's company than the South Hemisphære hath (as is plain to every one's Observation) for it is eight dayes more from the Vernal to the Autumnal Æquinox, then it is from the Autumnal to the Vernal again; which inequality will be repaid to our Antœci in one Revolution of the Sun's *Apogæum*: for 5000. years hence, both Hemisphæres will equally enjoy the Sun's illuminating presence; and 5000. years after that, the Southern Hemisphære will have the eight supernumerary dayes transferr'd to them; and then at the period of the last 5000. years, both Hemisphæres will be equilibrated again: Therefore, in all reason, those Southern Inhabitants may expect, and we must grant one Revolution of the Sun's *Apogæum*, at least, (which is 15000. years) yet to come, to

ballance our felicities in this world; and who knows, but it may be continued many more Revolutions?

Thus much for the *Macrocosm*: Now what decay there is in the *Microcosm*, we must be both Parties and Judges; and how far our Modern Wits have outdone the Ancient Sages, the parallel 'twixt the few Inventions of the one, and the rare Discoveries of the other, will easily determine. But the Learned *Hackwell's* Apology shall be mine at present, for not treating any further of this Subject; he having long since perform'd that Task, to the conviction of Prejudice it self.

Besides this Catholick one, there are other Remora's yet in the way, that have been accessory hindrances to the advancement of Learning, and that is, A diffidence and desperation of most men (nay even of those of more discerning faculties) of ever reaching to any eminent Invention; and an inveterate conceit they are possess'd with of the old Maxim, That *Nil dictum, quod non prius dictum*: by which despondency of mind, they have not onely stifled the blossoming of the Tree of Knowledge in themselves, but also have nipp'd the very Buds and Sproutings of it in others, by blazing about the old and uncomfortable Aphorism of our *Hippocrates*, of Nature's obscurity, the Life's brevity, the Senses fallacy, and the Judgement's infirmity.

Had the winged Souls of our modern Hero's been lime-twig'd with such ignoble conceptions as these, they had never flown up to those rare Inventions with which they have so enrich'd our latter dayes; we had wanted the useful Inventions of Guns, Printing, Navigation, Paper, and Sugar; we had wanted Decimal and Symbolical Arithmetick, the Analytical Algebra, the Magnetical Philosophy, the Logarithms, the Hydrargyral

gyral Experiments, the glorious Inventions of Dioptrick Glaffes, Wind-guns, and the Noble Boyle's Pneumatick Engine.

Nay, what strangers had we been at home, and within the circle of our own selves? We had yet never known the Mesenterical and Thoracical *Lactææ*, the Blood's Circulation, the Lymphiducts, and other admirable Curiosities in this fabrick of our Selves.

All which incomparable Inventions do not only solite, but, me-thinks, should inflame our endeavours to attempt even Impossibilities, and to make the world know There are not difficulties enough, in Philosophy, for a vigorous and active Reason: 'Tis a Noble resolution to begin there where all the world has ended; and an Heroick attempt to salve those difficulties (which former Philosophers accounted *impossibilities*) though but in an Ingenious Hypothesis: And, certainly, there is no Truth so abstruse, nor so far elevated out of our reach, but man's wit may raise Engines to Scale and Conquer it: Though *Democritus* his pit be never so deep, yet by a long *Sorites* of Observations, and chain of Deductions, we may at last fathom it, and catch hold of Truth that hath so long sitt forlorn at bottom thereof.

But these are Reaches that are beyond all those of the *Stagyrite's* Retinue, the Solutions of all those former Difficulties are reserved for you (most Noble Souls, the true Lovers of Free, and Experimental Philosophy) to gratifie Posterity withall.

You are the enlarged and Elastical Souls of the world, who, removing all former rubbish, and prejudicial resistances, do make way for the Springy Intellect to flye out into its desired Expansion. When I seriously contemplate the freedom of your Spirits, the excellency of
your

your Principles, the vast reach of your Designs, to unriddle all Nature ; me-thinks, you have done more than men already, and may be well placed in a rank Specifically different from the rest of groveling Humanity.

And this is the Age wherein all mens Souls are in a kind of fermentation, and the spirit of Wisdom and Learning begins to mount and free it self from those drossie and terrene Impediments wherewith it hath been so long clogg'd, and from the insipid phlegm and *Caput Mortuum* of useless Notions, in which it has endured so violent and long a fixation.

This is the Age wherein (me-thinks) Philosophy comes in with a Spring-tide; and the Peripateticks may as well hope to stop the Current of the Tide, or (with *Xerxes*) to fetter the Ocean, as hinder the overflowing of free Philosophy: Me-thinks, I see how all the old Rubbish must be thrown away, and the rotten Buildings be overthrown, and carried away with so powerful an Inundation. These are the days that must lay a new Foundation of a more magnificent Philosophy, never to be overthrown: that will Empirically and Sensibly canvass the *Phænomena* of Nature, deducing the Causes of things from such Originals in Nature, as we observe are producible by Art, and the infallible demonstration of Mechanicks: and certainly, this is the way, and no other, to build a true and permanent Philosophy: For Art, being the Imitation of Nature (or, Nature at Second-Hand) it is but a sensible expression of Effects, dependent on the same (though more remote Causes;) and therefore the works of the one, must prove the most reasonable discoveries of the other. And to speak yet more close to the point, I think it is no Rhetorication to say, That all things are Artificial; for Nature it self is
nothing

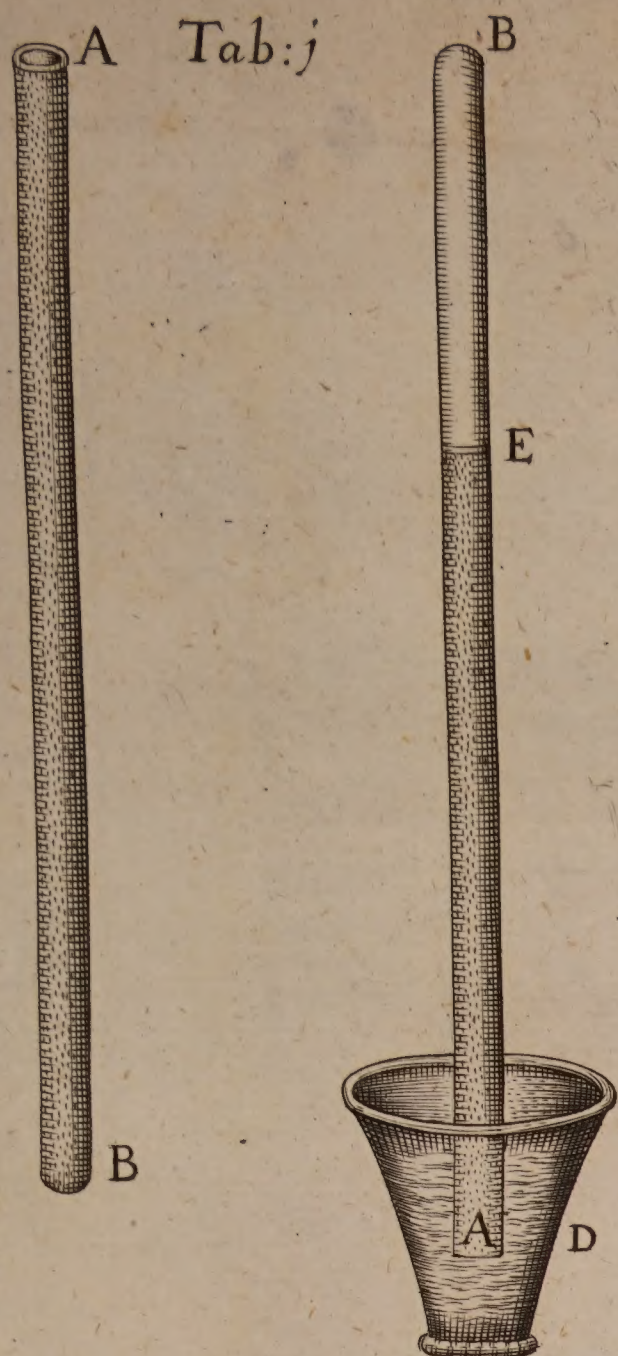
nothing else but the Art of God. Then, certainly, to find the various turnings, and myſterious proceſs of this divine Art, in the management of this great Machine of the World, muſt needs be the proper Office of onely the Experimental and Mechanical Philoſopher. For the old Dogmatists and Notional Speculators, that onely gaz'd at the viſible effects and laſt Reſultances of things, underſtood no more of Nature, than a rude Countrey-fellow does of the Internal Fabrick of a Watch, that onely ſees the Index and Horary Circle, and perchance hears the Clock and Alarum ſtrike in it: But he that will give a ſatisſactory Account of thoſe *Phænomena*, muſt be an Artificer indeed, and one well ſkill'd in the Wheel-work and Internal Contrivance of ſuch Anatomical Engines.

FINIS.

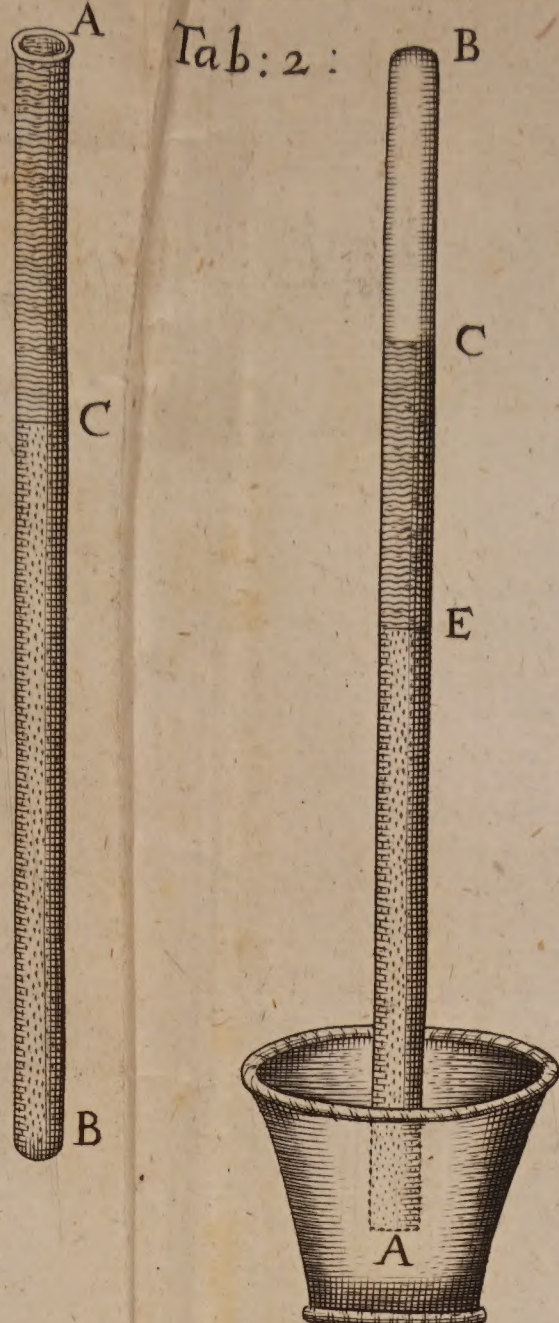
1784
The first of the year
was a very cold one
and the snow lay
on the ground for
many days. The
winter was very
severe and the
people suffered
much from the
cold. The snow
was very deep
and the people
could not go
out without their
clothes. The
people were very
poor and they
could not afford
to buy new
clothes. They
were very
suffering from
the cold and
the snow. The
people were very
poor and they
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to buy new
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1784

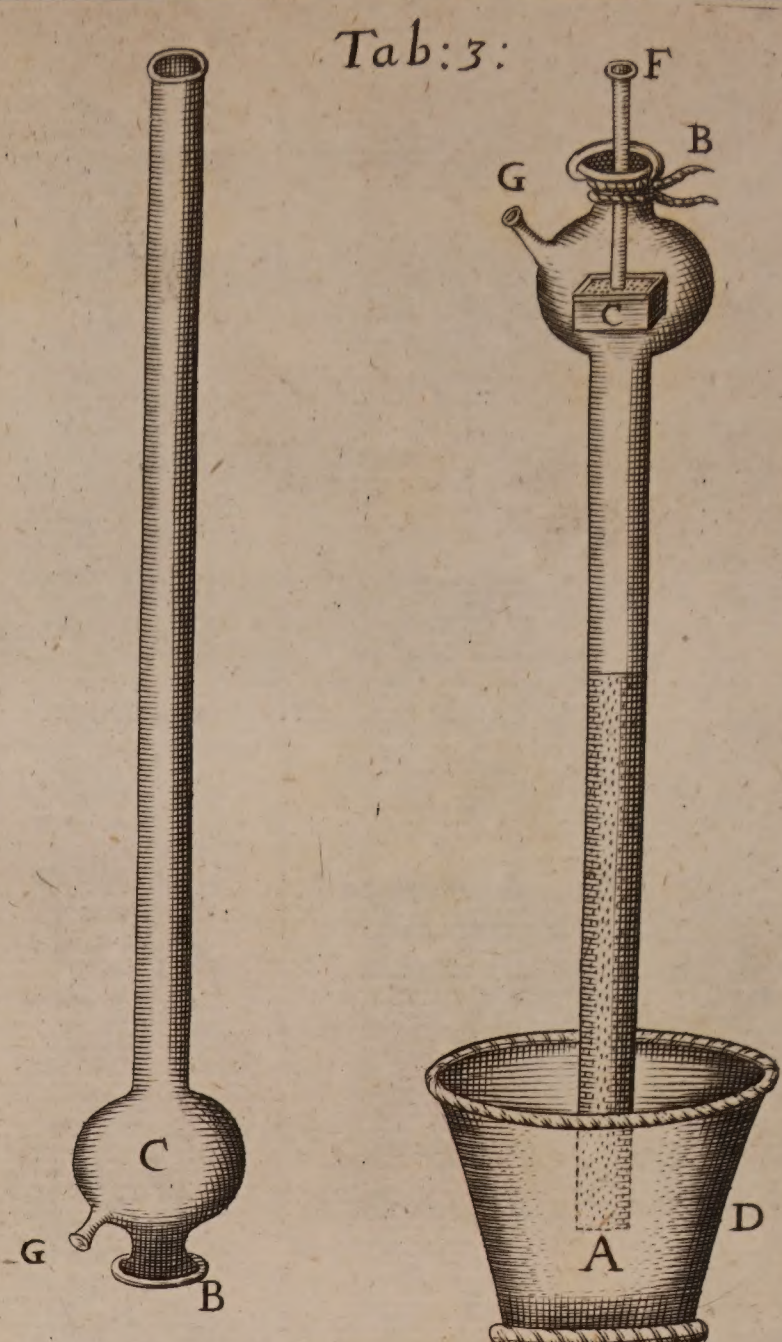
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Tab:2



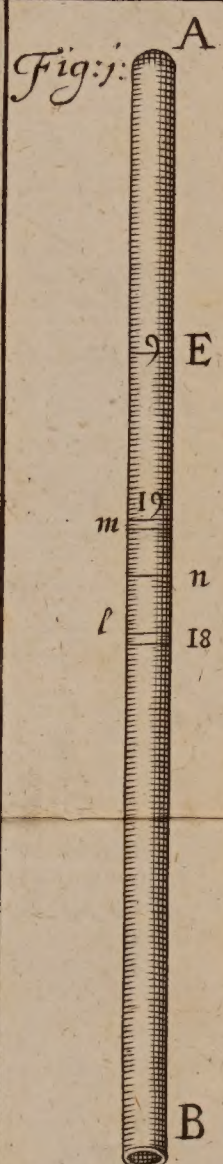
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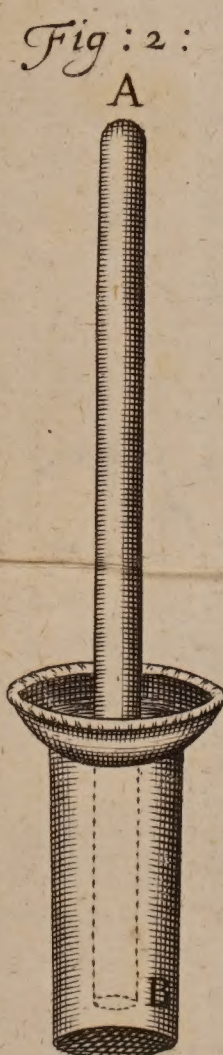
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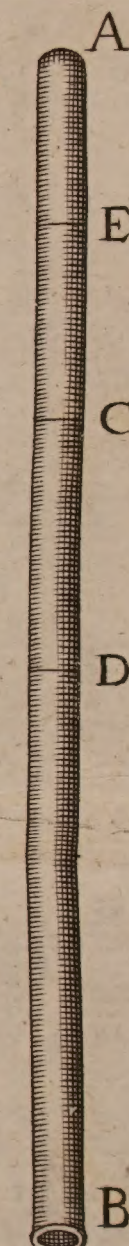
Fig:1



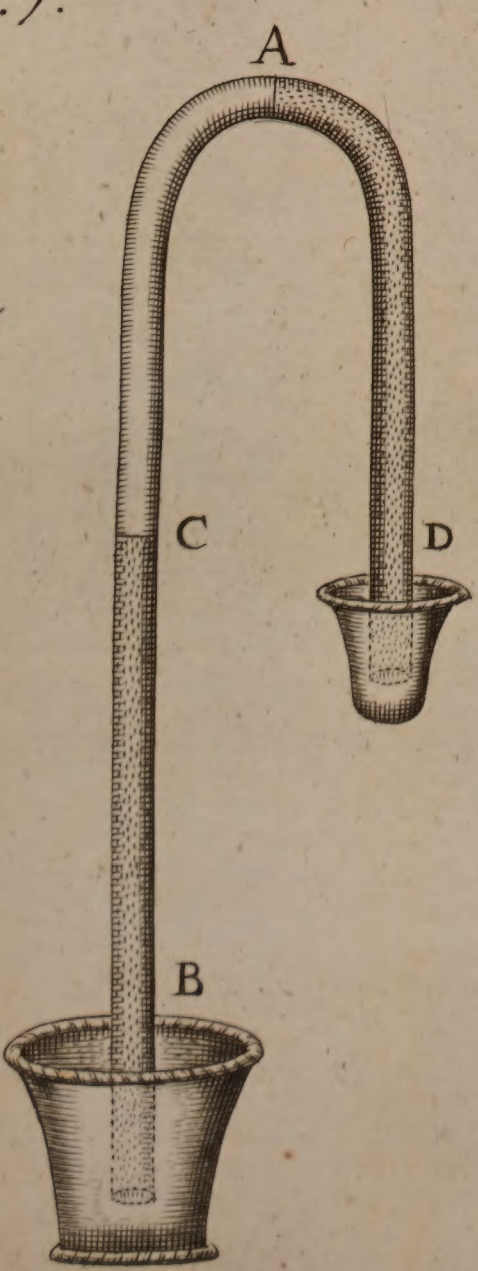
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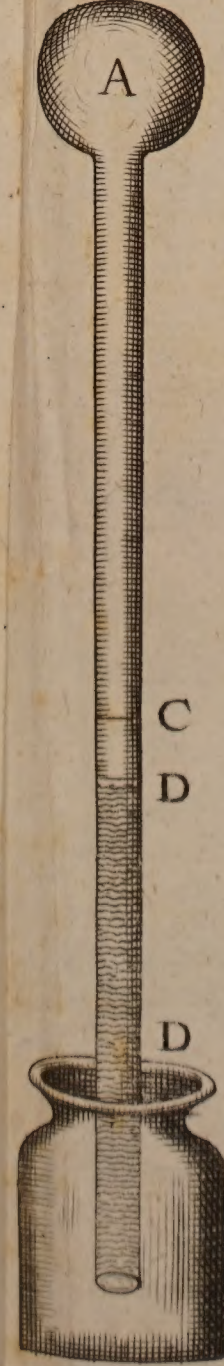
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Tab:7



Tab:8



Tab:9

